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ABSTRACT

One of a series of training manuals prepared for enlisted personnel in the Navy and Naval Reserve, this self-study package provides subject matter that relates directly to the occupational qualifications of the Aerographer's Mate rating. Contents include a 17-chapter text, a 15-item appendix followed by a subject index and the associated nonresident career course (twelve reading assignments and technical questions based on the 17 chapters). Chapter headings are (1) Aerographer's Mate Rating, (2) Pressure, (3) Wind Equipment, (4) Temperature, Humidity, and Precipitation, (5) Clouds and Visibility, (6) Radar and Satellite Equipment, (7) Communications Equipment and Operational Procedures, (8) Office Equipment, (9) Specialized Meteorological Equipment and Their Uses, (10) Watch Routine, (11) Watch Routines (Continued); (12) The Governing Fundamentals of Meteorology, (13) Circulation of the Atmosphere, (14) Air Masses and Fronts, (15) Meteorological Elements, (16) Fundamentals of Oceanography, and (17) Administration, Publications, and Supply. (HD)

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AEROGRAPHER'S MATE 3 & 2

NAVAL EDUCATION AND TRAINING COMMAND

RATE TRAINING MANUAL
AND NONRESIDENT CAREER COURSE

NAVEDTRA 10363-E

2

CE 008 671

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PREFACE

The ultimate purpose of training Naval personnel is to produce a combatant Navy which can ensure victory at sea. A consequence of the quality of training given them is their superior state of readiness. Its result is a victorious Navy.

This Rate Training Manual and Nonresident Career Course (RTM/NRCC) form a self-study package that will enable ambitious Aerographer's Mates to help themselves fulfill the requirements of their rating.

Designed for individual study and not formal classroom instruction, the RTM provides subject matter that relates directly to the occupational qualifications of the Aerographer's Mate rating. The NRCC provides the usual way of satisfying the requirements for completing the RTM. The set of assignments in the NRCC includes learning objectives and supporting items designed to lead students through the RTM.

The Rate Training Manual and Nonresident Career Course were prepared by the Naval Education and Training Program Development Center, Pensacola, Florida, for the Chief of Naval Education and Training. Technical assistance was provided by the Aerographer's Mate School, Lakehurst, New Jersey and Naval Weather Service Facility, Pensacola, Florida.

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THE UNITED STATES NAVY

GUARDIAN OF OUR COUNTRY

The United States Navy is responsible for maintaining control of the sea and is a ready force on watch at home and overseas, capable of strong action to preserve the peace or of instant offensive action to win in war.

It is upon the maintenance of this control that our country's glorious future depends; the United States Navy exists to make it so.

WE SERVE WITH HONOR

Tradition, valor, and victory are the Navy's heritage from the past. To these may be added dedication, discipline, and vigilance as the watchwords of the present and the future.

At home or on distant stations we serve with pride, confident in the respect of our country, our shipmates, and our families.

Our responsibilities sober us; our adversities strengthen us.

Service to God and Country is our special privilege. We serve with honor.

THE FUTURE OF THE NAVY

The Navy will always employ new weapons, new techniques, and greater power to protect and defend the United States on the sea, under the sea, and in the air.

Now and in the future, control of the sea gives the United States her greatest advantage for the maintenance of peace and for victory in war.

Mobility, surprise, dispersal, and offensive power are the keynotes of the new Navy. The roots of the Navy lie in a strong belief in the future, in continued dedication to our tasks, and in reflection on our heritage from the past.

Never have our opportunities and our responsibilities been greater.

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CHAPTER 1

AEROGRAPHER'S MATE RATING

This Rate Training Manual is designed as a self-study text for use by those personnel of the Navy and Naval Reserve who are preparing to meet the professional (technical) qualifications for advancement to Petty Officer Third Class and Petty Officer Second Class in the Aerographer's Mate (AG) rating. A second purpose of this manual is the improvement of job skills. This purpose is achieved through use of the manual as a study aid in conjunction with on-the-job training.

Minimum professional qualifications for advancement in all ratings are listed in the Manual of Navy Enlisted Manpower and Personnel Classifications and Occupational Standards, NAVPERS 18068 (Series). Formerly designated as the Manual of Qualifications for Advancement, NAVPERS 18068 is often referred to as the "Quals" Manual.

The occupational standards upon which this Rate Training Manual is based are those appearing in Change C of NAVPERS 18068. It should be kept in mind that any changes in the qualifications occurring after the (C) revision of the "Quals" Manual may not be reflected in the information presented in this training manual.

This chapter provides information on the enlisted rating structure, the AG rating, requirements and procedures for advancement, and references that will help you in working for advancement and in performing your duties as an AG. Also included is information on how to make the best use of Rate Training Manuals. It is therefore strongly recommended that you study this chapter carefully before beginning intensive study of the remainder of the manual.

ENLISTED RATING STRUCTURE

The present enlisted rating structure consists of general ratings and service ratings.

General ratings identify broad occupational fields of related duties and functions. Some general ratings include service ratings; others do not. Both Regular Navy and Naval Reserve personnel may hold general ratings.

The general rating provides the primary means of identifying billet requirements and personnel qualifications; it is established or disestablished by the Secretary of the Navy; and it is provided a distinctive rating badge. The general rate is the pay grade level within the general rating.

Service ratings identify subdivisions or specialities within a general rating which require related patterns of aptitudes and qualifications, and which provide paths of advancement for career development. Although service ratings can exist at any petty officer level, they are most common at the PO3 and PO2 levels. Both Regular Navy and Naval Reserve personnel may hold service ratings.

The Navy Enlisted Classification Coding System (NEC) has been set up to help the Navy match the right person with the right job. By identifying billets that require special skills, and by identifying people who have or can develop these special skills, the NEC system provides the Navy with a means of getting maximum usefulness from its manpower. Any person who gains the qualifications associated with one of the special skills is given a code number called his NEC.

AEROGRAPHER'S MATE RATING

Due to the demands of World War I, the United States Navy in 1917 designated some men as aerological personnel for the first time. The first group consisted of two hundred men of various ratings who received special training in meteorology.

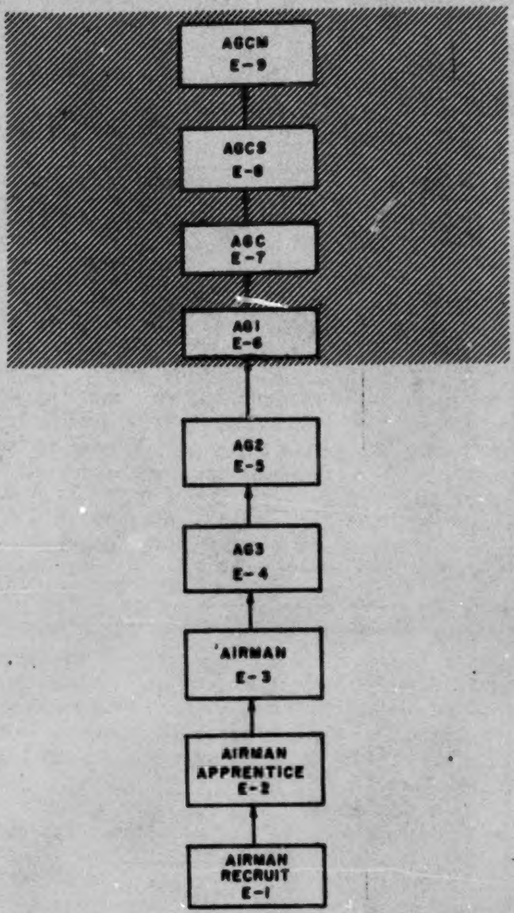
The first aerological personnel held the rating of Quartermaster with meteorological duties (QMA). This was changed in 1923 to Aerographer (Aerog). With the establishment of the warrant rank in 1942, the rating became Aerographer's Mate (AerM). In 1948 the rating became Aerographer's Mate (AG), which is one of the Group IX or aviation ratings. There is no service rating provided for Aerographer's Mates.

Figure 1-1 illustrates all paths of advancement for an Airman Recruit to Master Chief Aerographer's Mate (AGCM). Notice that each enlisted pay grade has a name; for example, E-1, recruit. An E-4 is called Aerographer's Mate 3rd class; an E-9 is called Master Chief Aerographer's Mate.

Figure 1-2(A) illustrates the active duty advancement requirements from E-1 through E-9. Figure 1-2(B) illustrates the inactive duty advancement requirements.

It is difficult to differentiate the type of work performed at various rate levels of the Aerographer's Mate rating. The work largely depends upon the mission of the weather unit and the personnel available to accomplish the mission. However, an attempt will be made to generalize the basic duties of the two lower rates.

As an Aerographer's Mate 3, you must be able to operate weather facsimile and teletype equipment; Automatic Picture Transmission (APT) Satellite receiving equipment; perform routine checks and operator's preventive maintenance of meteorological and oceanographic equipment; make, record, and prepare for transmission surface and upper wind observations; decode weather codes and plot data on surface and upper air charts; decode and plot oceanographic data; decode and plot a radiological fallout message; and typewrite for 5 minutes at 20 words per minute.



209.1
Figure 1-1.—Path of advancement.

As an Aerographer's Mate 3, you must know the application of basic laws of motion, gases, heat, and energy to meteorology; general characteristics of air masses and basic frontal systems; structure and composition of the atmosphere; precautionary measures to be observed in the care and handling of meteorological, oceanographic, and Naval Environmental Data Network (NEDN) tie-line equipment; operating principles and functions of standard nonelectronic meteorological and oceanographic instruments; meteorological and oceanographic terminology; legends used on analyzed charts; common symbols and codes used in surface, upper air, airways, and oceanographic observations; and principles and procedures of visual upper wind observations (PIBAL), of meteorological satellite observations, and of sea condition observations.

As an Aerographer's Mate 2, you must be able to sketch synoptic meteorological surface

REQUIREMENTS *	E1 to E2	E2 to E3	# E3 to E4	# E4 to E5	E5 to E6	† E6 to E7	† E7 to E8	† E8 to E9
SERVICE	4 mos. service—or completion of Recruit Training.	8 mos. as E-2.	6 mos. as E-3. 2 years time in service.	12 mos. as E-4. 3 years time in service.	24 mos. as E-5. 6 years time in service.	36 mos. as E-6. 9 years time in service.	36 mos. as E-7. 8 of 12 years time in service must be enlisted.	36 mos. as E-8. 10 of 15 years time in service must be enlisted.
SCHOOL	Recruit Training. (C.O. may advance up to 10% of graduating class.)	▨	Class A for PR3, DT3, PT3, AME 3, HM 3, PN 3, FTB 3, MT 3,	▨	▨	Navy School for AGC, MUC, MNC.††		
PERFORMANCE TEST	▨	▨	Specified ratings must complete applicable performance tests before taking examinations.				▨	▨
ENLISTED PERFORMANCE EVALUATION	As used by CO when approving advancement.		Counts toward performance factor credit in advancement multiple.					
EXAMINATIONS **	Locally prepared tests.	See below.	Navywide examinations required for all PO advancements.			Navywide selection board.		
RATE TRAINING MANUAL (INCLUDING MILITARY REQUIREMENTS)	▨	Required for E-3 and all PO advancements unless waived because of school completion, but need not be repeated if identical course has already been completed. See NAVEDTRA 10052 (current edition).					Nonresident career courses and recommended reading. See NAVEDTRA 10052 (current edition).	
AUTHORIZATION	Commanding Officer		NAVEDTRAPRODEVCEN					

* All advancements require commanding officer's recommendation.
† 3 years obligated service required for E-7, E-8, and E-9.
# Military leadership exam required for E-4 and E-5.
** For E-2 to E-3, NAVEDTRAPRODEVCEN exams or locally prepared tests may be used.
†† Waived for qualified EOD personnel.

Figure 1-2(A).—Active duty advancement requirements.

REQUIREMENTS *	E1 to E2	E2 to E3	E3 to E4	E4 to E5	E5 to E6	E6 to E7	E8	E9
TOTAL TIME IN GRADE	4 mos.	6 mos.	6 mos.	12 mos.	24 mos.	36 mos.	36 mos.	24 mos.
TOTAL TRAINING DUTY IN GRADE †	14 days	14 days	14 days	14 days	28 days	42 days	42 days	28 days
PERFORMANCE TESTS	▨		Specified ratings must complete applicable performance tests before taking examination.					
DRILL PARTICIPATION	Satisfactory participation as a member of a drill unit in accordance with BUPERSINST 5400.42 series.							
RATE TRAINING MANUAL (INCLUDING MILITARY REQUIREMENTS)	Completion of applicable course or courses must be entered in service record.							
EXAMINATION	Standard Exam		Standard Exam required for all PO Advancements. Also pass Military Leadership Exam for E-4 and E-5.				Standard Exam, Selection Board.	
AUTHORIZATION	Commanding Officer		Naval Examining Center					

Figure 1-2(B).—Inactive duty advancement requirements.

and upper aircharts; decode and plot APT predict messages and extract tracking data; demonstrate APT satellite gridding procedures and techniques; and construct and prepare for transmission a radiological fallout plot. The AG2 must also be capable of analyzing bathythermograph data for mixed or sonic layer depths and for thermal gradients and sound channels and of analyzing sea condition charts. He must also interpret oceanographic analyses and forecasts for operational use, and maintain weather office files of applicable notices, instructions, and manuals.

As an AG2, if you are to perform the tasks referred to in the preceding paragraphs, you must know the primary, secondary, and tertiary circulations of the earth's atmosphere; types of weather associated with fronts, air masses, and cyclonic and anticyclonic systems; basic functions and general operating principles of standard electronic meteorological and oceanographic instruments; and the physical properties of sea water and major current systems and water masses of the oceans. You must also know the principles and procedures of radiosonde and rawinsonde observations, the principles of radar observations, and the procedures for requisitioning meteorological supplies, equipments, and publications.

From the above general description of the professional requirements of Aerographer's Mates 3 and 2, you can readily see that only the highest caliber of personnel are desired for training as Aerographer's Mates.

As Aerographer's Mates, you are aware that there are many types of billets to which men of your rating may be assigned. A person contemplating a 20-year naval career could not, if serving normal duty tours, serve in each type billet to which Aerographer's Mates are assigned. A few types of duty assignments are Fleet Weather Centrals, instructor duty, polar expeditions, naval air stations, and shipboard duty on various types of ships.

As for the future, it is impossible to anticipate the billets that will be established and the ones that will be abolished. Technical developments; changes in policy, organization, and operational requirements; and modification of meteorological concepts will all play a part in the determination of the billets of the future.

It might be profitable to explore a few billets by tracing the possible career of one Aerographer's Mate for his first 4-year enlistment. Assume that the man was assigned to a fleet weather central in the United States upon graduating from Aerographer's Mate School, Class A, and was classified as an AGAN. The man was given the job of taking surface weather observations and entering synoptic reports on a weather chart. At first this work was done under close supervision. At times he assisted in taking pibals or rawins and radiosonde observations.

After a 6-month period, assume that he completed the prescribed practical factors and successfully passed the rating examination and was advanced to Aerographer's Mate, Third Class. He continued to do the same type of work, but with less supervision. He also began learning to analyze weather charts and to make short-range forecasts. One year after being advanced to AG3 and upon the successful completion of the advancement requirements and passing the rating examination, he was advanced to Aerographer's Mate, Second Class. After his normal tour of shore duty expired, he was transferred to an aircraft carrier. Aboard ship he took surface and upper air observations and supervised lower rated personnel. At times he ordered supplies and made out monthly and quarterly reports. Occasionally he analyzed weather charts and made short-range forecasts. During his tour of duty aboard the aircraft carrier his enlistment expired.

During this 4-year period he has been a part of the Navy. He has learned what it is to be a part of an organization. During the latter portion of his enlistment, he must give this one question some very serious thought: Shall I make the Navy my career? By this time he has been told of the many benefits the Navy affords, such as pay, travel, fringe, and retirement. With this knowledge of the security and monetary gains the Navy gives him, he also has the feeling of pride that being a part of the Navy team gives him. He knows that he is playing an important role in the defense of our democratic way of life, and to preserve this way of life, he will want to keep on being a member of this Navy team. After carefully studying the situation, he will realize that by making the Navy his career, he will be doing his country, his family, and himself a great service.

Since you have been in pay grade E-3 or E-4 for some time, you realize that more leadership is required of the higher rates. Not only are you required to have superior knowledge, but you are also required to have the ability to handle personnel. This ability increases in importance as you advance through the various rates as a petty officer.

In General Order No. 21, the Secretary of the Navy outlined some of the most important aspects of naval leadership. By naval leadership is meant the art of accomplishing the Navy's mission through people. It is the sum of those qualities of intellect, of human understanding, and of moral character that enables a person to inspire and to manage a group of people successfully. Effective leadership, therefore, is based on personal example, good management practices, and moral responsibility. The term leadership includes all three of these elements.

The current Navy Leadership Program is designed to keep the spirit of General Order No. 21 ever before you. If the threefold objective is carried out effectively in every command, the program will make you a better leader of men in your present billet and in your future assignments. As you advance up the ladder of leadership, your worth to the Navy will be judged increasingly on the basis of the amount of efficient work you obtain from your subordinates rather than how much of the actual work you do yourself.

For information on the practical application of leadership and supervision, study Military Requirements for Petty Officer 3 & 2, NAVEDTRA 10056 (Series).

ADVANCEMENT

Both you and the Navy benefit from your advancement. You get more pay, and your assignments are more interesting and challenging. You can enjoy getting ahead in the Navy on your own efforts. Highly trained personnel are essential to the functioning of the Navy. By advancement, you increase your value to the Navy in two ways: First, you become more valuable as a technical specialist in your own rating; and second, you become more valuable as a person who can train others, and thus make far-reaching contributions to the entire Navy.

The advancement system includes those requirements that must be met before you may be considered for advancement and those factors that actually determine whether or not you will be advanced. In this part of this chapter information is presented to help you prepare and become qualified for advancement and to inform you of the method used for selecting those who will be advanced.

BUPERS Notice 1418 will give you information on advancement examinations. Have your Educational Services Officer or your Training Petty Officer explain parts of these notices you do not understand.

PREPARING FOR ADVANCEMENT

What must you do to prepare for advancement? You must study the qualifications for advancement, complete the Personnel Advancement Requirements, study the required Rate Training Manuals and other material that is required. You will need to be familiar with the following:

1. Manual of Navy Enlisted Manpower and Personnel Classifications and Occupational Standards, NAVPERS 18068 (Series).
2. Personnel Advancement Requirements, NAVPERS 1414/4.
3. Bibliography for Advancement Study, NAVEDTRA 10052 (Series).
4. Applicable Rate Training Manuals and their companion Nonresident Career Courses.
5. Examination for advancement procedures.

Collectively, these documents make up an integrated training package tied together by the occupational standards. The following paragraphs describe these materials and gives some information on how each one is related to the others.

"Quals" Manual

The Manual of Navy Enlisted Manpower and Personnel Classifications and Occupational Standards, NAVPERS 18068 (Series), gives the minimum requirements for advancement. This manual is usually called the "Quals" Manual, and the qualifications themselves are called occupational standards. The "Quals" Manual can be found in your Educational Services Office or may be obtained from your Training Petty Officer.

Occupational standards are expressed as task statements only, unlike the advancement qualifications which contain practical factors and knowledge factors. The approved concept for occupational standards is that they define what enlisted personnel must do in their rate or rating and that the knowledges required to perform a task are inherent to the proper performance of the task. The practical and knowledge factors presently in the "Quals" Manual will be replaced with occupational standards.

Occupational standards are identified by a five-digit number of which the first two digits identify the standard topic title and the remaining three digits identify the specific task statement.

NOTE: As stated previously, the occupational standards upon which this Rate Training Manual is based are those appearing in NAVPERS 18068-C, which is titled Manual of Qualifications for Advancement. Therefore, the material is based on practical and knowledge factors which are identified by alphanumeric codes. For example, B1.01, "Operate facsimile and teletype equipment," is a knowledge factor under this system. In the new NAVPERS 18068 (Series), Manual of Navy Enlisted Manpower and Personnel Classifications and Occupational Standards, the above occupational standard will probably appear as 86272, "Operate radio receivers, facsimile and teletype equipment." Any reference to qualifications or occupational standards in this manual pertains to the old system.

The standards are of two general types: military requirements and professional (or technical) requirements.

Military requirements apply to all ratings rather than to any one particular rating. Military requirements for advancement to third class and second class petty officer rates deal with military conduct, naval organization, military justice, security, watch standing, and other subjects which are required of petty officers in all other ratings.

Professional requirements are technical or professional in nature and are directly related to the work of each rating. Both the military requirements and the professional requirements are divided into subject matter groups; then within each subject matter group, they are divided into specific task statements.

The occupational standards for AG are listed in this manual following the index. Study these standards and the military requirements carefully. The majority of the questions on your advancement examination will try to determine your understanding of the requirements reflected in the occupational standards. If you are working for advancement to second class, remember that you may be examined on third class occupational standards as well as on second class occupational standards.

It is essential that the occupational standards reflect current requirements of fleet and shore operations, and that new fleetwide technical, operational, and procedural developments be included. For these reasons, the occupational standards are continually under evaluation. Although there is an established schedule for revisions to the occupational standards for each rating, urgent changes to the occupational standards may be made at any time. These revisions are issued in the form of changes to the "Quals" Manual. Therefore, never trust any set of occupational standards until you have checked the change number against an up-to-date copy of the "Quals" Manual. Be sure you have the latest revision.

PERSONNEL ADVANCEMENT REQUIREMENT (PAR) PROGRAM NAVPERS 1414/4

The Personnel Advancement Requirement (PAR) Program is a new program initiated to replace the Record of Practical Factors (NAVEDTRA 1414/1).

The former "quals" were stated in terms of practical factors and knowledge factors. The new occupational standards are presented only as task statements. This new format of the occupational standards does not lend itself to the practical factor checkoff list concept of the Record of Practical Factors. As a result, a new form and new concept of determining eligibility for advancement has been developed. The Personnel Advancement Requirement (PAR) (NAVPERS 1414/4) will replace the Record of Practical Factors. This new system allows a command to evaluate the overall abilities of an individual in a day-to-day work situation, and eliminates the need to complete a mandatory, lengthy, and detailed checkoff list.

The E-8 and E-9 are exempt from the program as there are other means of selection for advancement to these paygrades. The E-3 apprenticeships are so broad as to make the development of a single PAR impractical.

Each rating PAR lists the requirements for advancement to paygrades E-4 through E-7 in one pamphlet. It contains descriptive information, instructions for administration, special rating requirements, and advancement requirements in the following sections:

Section I—Administration Requirements
Section II—Formal School and Training Requirements
Section III—Occupational and Military Ability Requirements

Section I contains the individuals' length of service, time in rate, and a checkoff for the individual having passed the E-4/E-5 Military Leadership Examination.

Section II contains a checkoff entry for the individual having completed the Military Requirements Navy Training Course and the applicable Navy Training Course for the rating.

Section III is a checkoff list of task statements. Items in this section are to be interpreted broadly and do not demand actual demonstration of the item, or completion of alternate local examination, although demonstration is a command prerogative. Individuals are evaluated on their ability to perform the task. Evaluation may be by observation of ability in related areas, training received, or by demonstration.

There is currently a pilot program which includes the PQS watch station qualifications and preventive maintenance actions as a separate section of the PAR form. Section III under this program lists task statements required of the rating which are not reflected in the PQS qualifications. As PQS qualifications are developed, PAR forms will be revised.

The Record of Practical Factors will remain in effect until 1 January 1977, at which time the PAR form will become effective.

PAR forms are stocked in the Navy Supply System.

Personnel Qualification Standards

Personnel Qualification Standards (PQS), described in OPNAV Instruction 3500.34, are presently being utilized to provide guidelines in preparing for advancement and qualification to operate specific equipment and systems. They are designed to support the advancement requirements as stated in the "Quals" Manual.

The occupational standards and Personnel Advancement Requirements are stated in broad terms. Each PQS is much more specific in its questions that lead to qualification. It provides an analysis of specific equipment and duties, assignments, or responsibilities which an individual or group of individuals (within the same rating) may be called upon to carry out. In other words, each PQS provides an analysis of the complete knowledge and skills required of that rating tied to a specific weapon system (aircraft and/or individual systems or components).

Each qualification standard has four main subdivisions in addition to an introduction and a glossary of PQS terms. They are as follows:

100 Series—Theory

200 Series—System

300 Series—Watchstations (duties, assignments or responsibilities)

400 Series—Qualification cards

The introduction explains the complete use of the qualification standard in terms of what it will mean to the user as well as how to use it.

The Theory (100 Series) section specifies the theory background required as a prerequisite to the commencement of study in the specific equipment or system for which the PQS was written. These fundamentals are normally taught in the formal schools (Preparatory, Fundamentals, and Class A) phase of an individual's training. However, if the individual has not been to school, the requirements are outlined and referenced to provide guidelines for a self-study program.

The Systems (200 Series) section breaks down the equipment or systems being studied into functional sections. PQS items are essentially questions asked in clear, concise statement (question) form and arranged in a standard format. The answers to the questions must be extracted from the various maintenance manuals covering the equipment or systems for which the PQS was written. This section asks the user to explain the function of the system, to draw a simplified version of the system from memory, and to use this drawn schematic or the schematic provided in the maintenance manual while studying the system or equipment. Emphasis is given to such areas as maintenance management procedures, components, component parts, principles of operation, system interrelations, numerical values considered necessary to operation and maintenance, and safety precautions.

The Watchstation (300 Series) section includes questions regarding the procedures the individual must know to operate and maintain the equipment or system. A study of the items in the 200 series section provides the individual with the required information concerning what the system or equipment does, how it does it, and other pertinent aspects of operation. In the 300 series section, the questions advance the qualification process by requiring answers or demonstrations of ability to put this knowledge to use or to cope with maintenance of the system or equipment. Areas covered include normal operation; abnormal or emergency operation; emergency procedures which could limit damage and/or casualties associated with a particular operation; operations that occur too infrequently to be considered mandatory performance items; and maintenance procedures/instructions such as checks, tests, repair, replacement, etc.

The 400 Series section consists of the qualification cards. These cards are the accounting documents utilized to record the individual's satisfactory completion of items necessary for becoming qualified in duties assigned. Where the individual starts in completing a standard will depend on his assignment within an activity. The complete PQS should be given to the individual being qualified so that he can utilize it at every opportunity to become fully qualified in all areas of his rating and the equipment or system for which the PQS was written. Upon transfer to a different activity, each individual must requalify. The answers to the questions asked in the qualification standards may be given orally or in writing to the supervisor, the branch or division officer, and maintenance officer as required to certify proper qualification. The completion of part or all of the PQS provides a basis for the supervising petty officer and officer to certify completion of the PQS section of the PAR (if applicable).

Bibliography for Advancement Study

The Bibliography for Advancement Study, NAVEDTRA 10052 (Series), is a very important publication for anyone preparing for advancement. This bibliography lists required and recommended Rate Training Manuals and other reference material to be used by personnel working for advancement. NAVEDTRA 10052 is revised and issued once each year by the Naval Education and Training Support Command. Each revised edition is identified by a letter following the NAVEDTRA number. When using this publication, be sure that you have the most recent edition.

If extensive changes in qualifications occur between the annual revisions of NAVEDTRA 10052, a supplementary list of study material may be issued in the form of a BUPERS Notice. When you are preparing for advancement, check with your Educational Services Officer or your Training Petty Officer to see whether changes have been made in the qualifications. If changes have been made, see if a BUPERS Notice has been issued to supplement NAVEDTRA 10052.

The required and recommended references are listed by rate level in NAVEDTRA 10052. If you are working for advancement to third class, study the material that is listed for third class. If you are working for advancement to second class, study the material that is listed for second class, and remember that you will also be examined on the references listed at the third class level.

NOTE: Personnel preparing for advancement will be examined on the TOTAL BIBLIOGRAPHY. Publications listed for a given paygrade frequently make specific reference to other publications. These specific referrals are part of the TOTAL BIBLIOGRAPHY. Emphasis must be placed on the military/technical TOTAL BIBLIOGRAPHY for each paygrade; examinations are based on it.

In using NAVEDTRA 10052, you will notice that some Rate Training Manuals are marked with an asterisk (*). Any manual marked in this way is MANDATORY—that is, it must be completed at the indicated rate level before you are eligible to take the Navy-wide examination for advancement. Each mandatory manual may be completed by passing the appropriate Nonresident Career Course that is based on the mandatory training manual; passing locally prepared tests based on the information given in the training manual; or in some cases, successfully completing an appropriate Class A School.

Do not overlook the front section of NAVEDTRA 10052 which lists the required and recommended references relating to the military standards/requirements for advancement. For example, all personnel must complete the Rate Training Manual, Military Requirements for Petty Officer 3 & 2, NAVPERS 10056 (Series), for the appropriate rate level before they can be eligible to advance.

The references in NAVEDTRA 10052 which are recommended, but not mandatory, should also be studied carefully. All references listed in NAVEDTRA 10052 may be used as source material for the written examinations at the appropriate rate levels.

Rate Training Manuals

There are two general types of Rate Training Manuals. Rating manuals (such as this one) are prepared for most enlisted rates, giving information that is directly related to the professional qualifications. Basic manuals give information that applies to more than one rate and rating. Basic Electricity, NAVPERS 10086 (Series), is an example of a basic manual because many ratings use it for reference.

Rate Training Manuals are revised from time to time to keep them up to date technically. The revision of a Rate Training Manual is identified by a letter following the NAVEDTRA number. You can tell whether any particular copy of a Rate Training Manual is the latest edition by checking the NAVEDTRA number and the letter following this number in the most recent edition of List of Training Manuals and Correspondence Courses, NAVEDTRA 10061 (Series). NAVEDTRA 10061 is a catalog that lists current training manuals and correspondence courses; you will find this catalog useful in planning your study program.

Rate Training Manuals are designed to help you prepare for advancement. The following suggestions may help you to make the best use of this manual and other Navy training publications when you are preparing for advancement.

1. Study the military requirements and the professional qualifications for your rate before you study the training manual, and refer to the occupational standards frequently as you study. Remember, you are studying the training manual in order to meet these occupational standards.

2. Set up a regular study plan. If possible, schedule your studying for a time of day when you will not have too many interruptions or distractions.

3. Before you begin to study any part of the training manual intensively, become familiar with the entire manual. Read the preface and the table of contents. Check through the index. Look at the appendixes. Thumb through the manual without any particular plan, looking at the illustrations and reading bits here and there as you see things that interest you.

4. Look at the training manual in more detail to see how it is organized. Look at the table of contents again. Then, chapter by chapter, read the introduction, the headings, and the subheadings. This will give you a clear picture of the scope and content of the manual. As you look through the manual in this way, ask yourself some questions: What do I need to learn about this? What do I already know about this? How is this information related to information given in other chapters? How is this information related to the occupational standards?

5. When you have a general idea of what is in the training manual and how it is organized, fill in the details by intensive study. In each study period, try to cover a complete unit—it may be a chapter, a section of a chapter, or a subsection. If you know the subject well, or if the material is easy, you can cover quite a lot at one time. Difficult or unfamiliar material will require more study time.

6. In studying any one unit—chapter, section, or subsection—write down the questions that occur to you. Many people find it helpful to make a written outline of the unit as they study, or at least to write down the most important ideas.

7. As you study, relate the information in the training manual to the knowledge you already have. When you read about a process, a skill, or a situation, try to see how this information ties in with your own past experience.

8. When you have finished studying a unit, take time out to see what you have learned. Look back over your notes and questions. Maybe some of your questions have been answered,

but perhaps you still have some that are not answered. Without referring to the training manual, write down the main ideas that you have learned from studying this unit. Do not quote the manual. If you cannot give these ideas in your own words, the chances are that you have not really mastered the information.

9. Use Nonresident Career Courses (NRCC) whenever you can. These courses are based on Rate Training Manuals or on other appropriate texts. As mentioned before, completion of a mandatory Rate Training Manual can be accomplished by passing a Nonresident Career Course based on the Rate Training Manual. You will probably find it helpful to take other courses in addition to those based on mandatory training manuals. Taking a Nonresident Career Course helps you to master the information given in the training manual, helps you to see how much you have learned, and can serve for refresher study.

10. Think of your future as you study Rate Training Manuals. You are working for advancement to third class or second class right now, but someday you will be working toward higher rates. Anything extra that you can learn now will help you.

Nonresident Career Course

The Nonresident Career Course (NRCC), formerly called Enlisted Correspondence Course, for this Rate Training Manual (RTM) has been included at the back of the manual. Its purpose is to assist you in the training necessary to fulfill your job and advancement requirements; it will be of benefit to you when preparing for the Navy-wide Advancement Examinations; and it reflects the more important information in the manual.

Included in the course are learning objectives which state knowledges you will acquire by choosing the correct answer to each question or by restudying until you can choose the correct answer. The questions are teaching tools that point out important things in the Rate Training Manual. The Nonresident Career Course is an important part of the training package presented within these covers.

The answer sheets to the NRCC, referred to as IKOR (immediate knowledge of results) sheets, are a separate package and are not included with this Rate Training Manual. A separate errata sheet may be included with this training package. If present, it will inform you of any changes in the text of the RTM or the NRCC. For complete instructions on this NRCC, read the preliminary pages thoroughly before you proceed with the course.

QUALIFYING FOR ADVANCEMENT

In general, to qualify (be considered) for advancement, you must:

1. Have a certain amount of time in your present pay grade.

2. Demonstrate knowledge of material in your mandatory Rate Training Manual by making a suitable score on your command's test on the manual, by successfully completing the NRCC on the manual, or, in some cases, by graduating from an appropriate Navy school.

3. Complete the Personnel Advancement Requirement (PAR) form, NAVPERS 1414/4.

4. Be recommended by your commanding officer, after the petty officers and officers supervising your work have indicated that they consider you capable of performing the duties of the next higher rate by recommending you for advancement to the commanding officer.

5. For petty officer third and second candidates only, demonstrate knowledge of military subjects by passing the MILITARY/LEADERSHIP examination based on the military occupational standards for advancement from NAVPERS 18068 (Series).

In addition to these requirements, to qualify for advancement you must demonstrate an understanding of the technical aspects of your rate by passing a Navy-wide advancement examination based on the occupational standards applicable to your rate (from NAVPERS 18068 (Series), those occupational standards listed at or below your rate level).

If you meet all of the above requirements satisfactorily, you are in a group from which advancements will be made.

WHO WILL BE ADVANCED?

Advancement is not automatic. Meeting all of the requirements makes you eligible but does not guarantee your advancement. Some of the factors that determine which persons, out of all of those qualified, will actually be advanced in rate are the score made on the advancement examination, the length of time in service, the performance marks earned, and the number of vacancies being filled in a given rate.

If the number of vacancies in a given rate exceed the number of qualified personnel, then all of those qualified will be advanced. More often, the number of qualified people exceeds the vacancies. When this happens, the Navy has devised a procedure for advancing those who are best qualified. This procedure is based on combining the three following personnel evaluation systems:

1. Merit rating system (Annual evaluation and C.O. recommendation)

2. Personnel testing system (Advancement examination score—with some credit for passing previous advancement exams)

3. Longevity (seniority) system (Time in rate and time in service)

Simply, credit is given for how much the individual has achieved in the areas of performance, advancement test, and seniority. A composite, known as the final multiple score, is generated from these three factors. All of the candidates who have PASSED the examination from a given advancement population are then placed on one list. Based on the final multiple score, the person with the highest multiple score is ranked first, and so on, down to the person with the lowest multiple score. For candidates for E-4, E-5, and E-6, advancement authorizations are then issued, beginning at the top of the list, for the number of persons needed to fill the existing vacancies.

Candidates for E-7 whose final multiple scores are high enough will be designated PASS SELBD ELIG (Pass Selection Board Eligible). This means that their names will be placed before the Chief Petty Officer Selection Board, a BUPERS board charged with considering all so-designated eligible candidates for advancement to CPO. Advancement authorizations for those being advanced to CPO are issued by this board.

Who, then, are the individuals who are advanced? Basically, they are the ones who achieved the most in preparing for advancement. They were not content to just qualify; they went the extra mile in their training, and through that training and their work experience they developed greater skills, learned more, and accepted more responsibility.

While it cannot guarantee that any one person will be advanced, the advancement system does guarantee that all persons within a particular rate will compete equally for the vacancies that exist and that the best qualified persons will be advanced.

EXAMINATION PROCEDURES

Examinations are given to candidates for advancement to E-4 through E-6 in February and August each year. E-7 through E-9 exams are given only once a year. The time and place of the examinations will be published in the Plan of the Day and in your station or unit paper. You must appear at the designated time and place in the uniform of the day and with your ID card. If you are to take the exam for AG3, no other person taking that exam will sit near you. This helps ensure that all taking the exam have an equal chance. The examiner or a proctor will read to you the instructions to be followed. Be sure you listen to and follow these instructions carefully.

You will have three hours. Each question on the exam will have four possible answers from which to choose the correct one. Read each question carefully and all of the possible answers. If you know the correct answer, mark your answer sheet. If you do not know the answer, go to the next question. This will ensure that you have time to answer all the questions to which you know the answers in the time allotted. Each time you mark the answer sheet make your mark in the same number as the question.

After you have gone through the exam and answered all the questions to which you know the answers, go through the exam again and answer the questions that you can limit to two probably correct answers. Then you can spend the remaining time considering the questions about which you have the least knowledge and checking the questions and answers you have already completed. When the allotted time has passed, the proctor will collect the examination booklets and the answer sheets.

SUBJECT-MATTER SECTION IDENTIFICATION SHEET

The Subject-Matter Section Identification Sheet (fig. 1-3) is a tear-out sheet included in your Navy-wide advancement examination booklet. It is to be detached from the examination booklet upon completion of the examination and given to the exam proctor. This sheet indicates the subject-matter sections of the examination which represent the occupational requirements for the rate. The occupational standards used to support the examination questions are also indicated for each subject-matter section. This sheet will be retained by the Educational Services Officer (ESO) for purposes of command review upon receipt of the Profile Analysis Form. Both of these forms will be made available to you for your review at a date subsequent to the date of examination.

PROFILE ANALYSIS FORM

The Profile Analysis Form (fig. 1-4) is provided to all candidates two or three months after competing in the Navy-wide advancement examination. Normally, this form will be made available to you by your ESO with the Subject-Matter Section Identification Sheet, previously discussed. The Profile Analysis Form is to be used in conjunction with the Subject-Matter Section Identification Sheet to indicate your strengths and weaknesses for the particular examination in which you competed.

The Profile Analysis Form (refer to fig. 1-4) indicates the candidate's relative standing in Section 1 of the examination as being "A" (Average-middle). Section 1, as indicated on the Subject-Matter Section Identification Sheet, dealt with questions relating to "Surface Observations." You can, therefore, conclude that your standing was average, in comparison with the rest of the candidates, for Section 1 of the examination, "Surface Observations". The occupational standards used to support the questions on "Surface Observations" were C1.01 and C2.01. The same procedure should be followed for the remaining sections of the examination.

By the use of these two forms you will be able to determine those areas where additional study could assist you in future examinations.

SOURCES OF INFORMATION

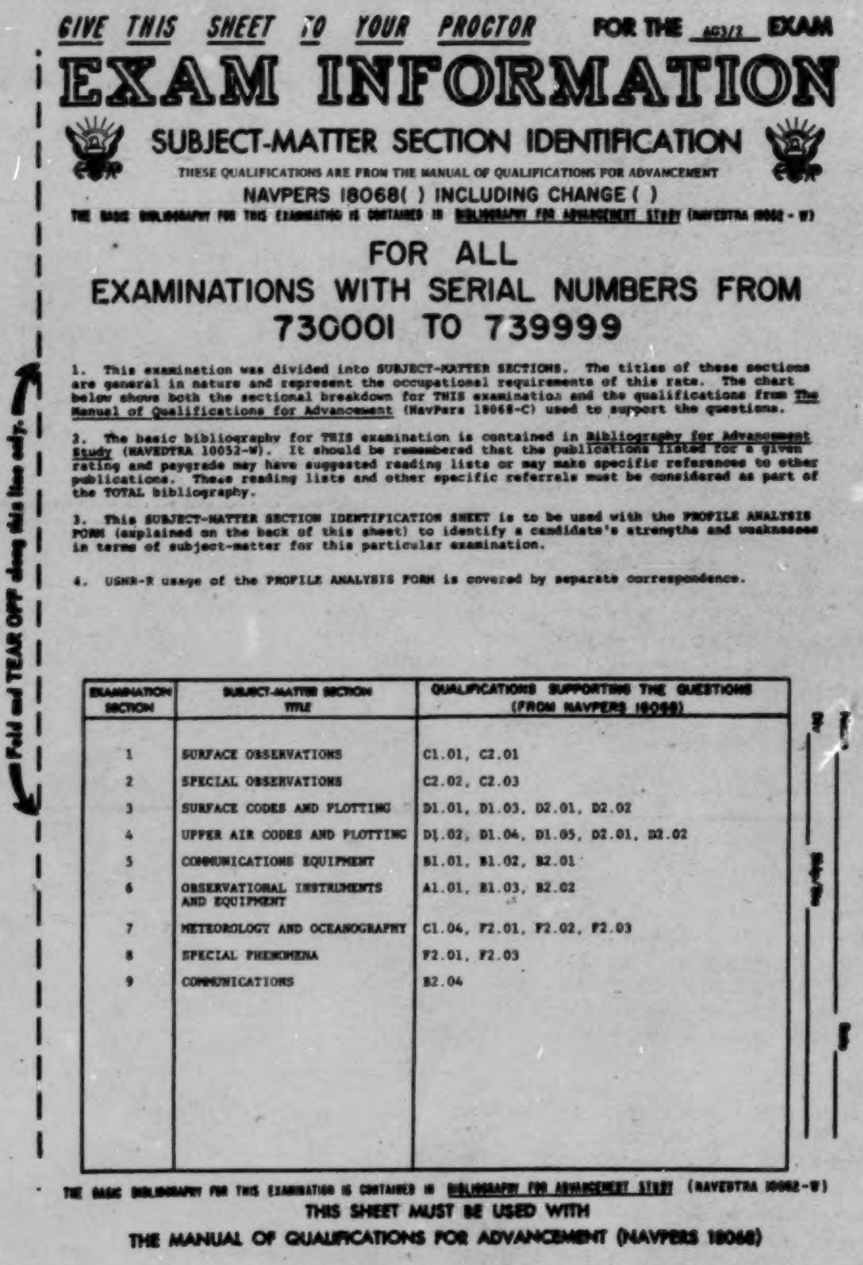
One of the most useful things you can learn about a subject is how to find out more about it. No single publication can give you all the information you need to perform the duties of your rating. You should learn where to look for accurate, authoritative, up-to-date information on all subjects related to the military requirements for advancement and the professional standards of your rating.

Some of the publications described in this manual are subject to change or revision from time to time—some at regular intervals, others as the need arises. When using any publication that is subject to change or revision be sure that you have the latest edition. When using any publication that is kept current by means of changes, be sure you have a copy in which all official changes have been made. Studying canceled or obsolete information will not help you perform efficiently or to advance; it is likely to be a waste of time, and may even be seriously misleading.

TRAINING FILMS

Training films available to naval personnel are a valuable source of supplementary information on many technical subjects. Training films are listed in the United States Navy Film Catalog, NAVAIR 10-1-777 (formerly NAVWEPS 10-1-777), published in 1969. Copies of this catalog may be ordered in accordance with the Navy Stock List of Forms and Publications, NAVSUP 2002. Monthly supplements to the Film Catalog are distributed to catalog holders. Check with your Training Petty Officer for the location of the nearest Film Catalog.

When selecting a film, note its date of issue listed in the Film Catalog. As you know, procedures sometimes change rapidly; thus, some films become obsolete rapidly. If a film is obsolete only in part, it may still be of some use.



GIVE THIS SHEET TO YOUR PROCTOR FOR THE AG3/2 EXAM

EXAM INFORMATION

SUBJECT-MATTER SECTION IDENTIFICATION

THESE QUALIFICATIONS ARE FROM THE MANUAL OF QUALIFICATIONS FOR ADVANCEMENT

NAVPERS 18068( ) INCLUDING CHANGE ( )

THE BASIC BIBLIOGRAPHY FOR THIS EXAMINATION IS CONTAINED IN BIBLIOGRAPHY FOR ADVANCEMENT STUDY (NAVEDTRA 10052 - W)

FOR ALL
EXAMINATIONS WITH SERIAL NUMBERS FROM
730001 TO 739999

1. This examination was divided into SUBJECT-MATTER SECTIONS. The titles of these sections are general in nature and represent the occupational requirements of this rate. The chart below shows both the sectional breakdown for THIS examination and the qualifications from The Manual of Qualifications for Advancement (NavPers 18068-C) used to support the questions.

2. The basic bibliography for THIS examination is contained in Bibliography for Advancement Study (NAVEDTRA 10052-W). It should be remembered that the publications listed for a given rating and paygrade may have suggested reading lists or may make specific references to other publications. These reading lists and other specific referrals must be considered as part of the TOTAL bibliography.

3. This SUBJECT-MATTER SECTION IDENTIFICATION SHEET is to be used with the PROFILE ANALYSIS FORM (explained on the back of this sheet) to identify a candidate's strengths and weaknesses in terms of subject-matter for this particular examination.

4. USNR-R usage of the PROFILE ANALYSIS FORM is covered by separate correspondence.

Fold and TEAR OFF along this line only.

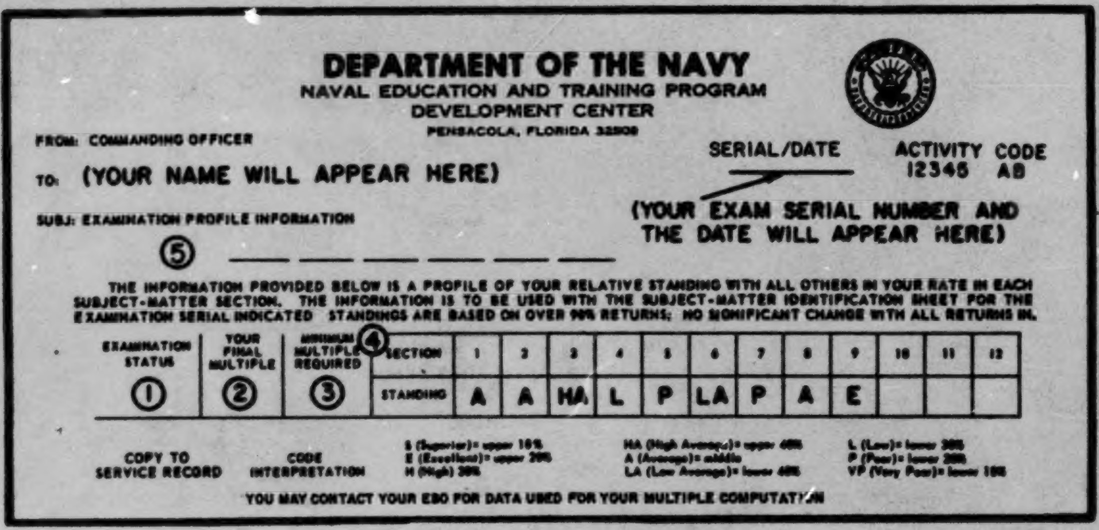
EXAMINATION SECTION	SUBJECT-MATTER SECTION TITLE	QUALIFICATIONS SUPPORTING THE QUESTIONS (FROM NAVPERS 18068)
1	SURFACE OBSERVATIONS	C1.01, C2.01
2	SPECIAL OBSERVATIONS	C2.02, C2.03
3	SURFACE CODES AND PLOTTING	D1.01, D1.03, D2.01, D2.02
4	UPPER AIR CODES AND PLOTTING	D1.02, D1.04, D1.05, D2.01, D2.02
5	COMMUNICATIONS EQUIPMENT	B1.01, B1.02, B2.01
6	OBSERVATIONAL INSTRUMENTS AND EQUIPMENT	A1.01, B1.03, B2.02
7	METEOROLOGY AND OCEANOGRAPHY	C1.04, F2.01, F2.02, F2.03
8	SPECIAL PHENOMENA	F2.01, F2.03
9	COMMUNICATIONS	B2.04

THE BASIC BIBLIOGRAPHY FOR THIS EXAMINATION IS CONTAINED IN BIBLIOGRAPHY FOR ADVANCEMENT STUDY (NAVEDTRA 10052-W)

THIS SHEET MUST BE USED WITH
THE MANUAL OF QUALIFICATIONS FOR ADVANCEMENT (NAVPERS 18068)

209.390

Figure 1-3.—Subject-matter section identification sheet.



DEPARTMENT OF THE NAVY
NAVAL EDUCATION AND TRAINING PROGRAM
DEVELOPMENT CENTER
PENSACOLA, FLORIDA 32508

FROM: COMMANDING OFFICER

TO: (YOUR NAME WILL APPEAR HERE)

SERIAL/DATE ______

(YOUR EXAM SERIAL NUMBER AND THE DATE WILL APPEAR HERE)

ACTIVITY CODE
12345 AB

SUBJ: EXAMINATION PROFILE INFORMATION

⑤ ____ ____ ____ ____ ____ ____

THE INFORMATION PROVIDED BELOW IS A PROFILE OF YOUR RELATIVE STANDING WITH ALL OTHERS IN YOUR RATE IN EACH SUBJECT-MATTER SECTION. THE INFORMATION IS TO BE USED WITH THE SUBJECT-MATTER IDENTIFICATION SHEET FOR THE EXAMINATION SERIAL INDICATED STANDINGS ARE BASED ON OVER 90% RETURNS; NO SIGNIFICANT CHANGE WITH ALL RETURNS IN.

EXAMINATION STATUS	YOUR FINAL MULTIPLE	MINIMUM MULTIPLE REQUIRED	④ SECTION	1	2	3	4	5	6	7	8	9	10	11	12
①	②	③	STANDING	A	A	HA	L	P	LA	P	A	E			

COPY TO SERVICE RECORD

CODE INTERPRETATION
S (Superior)= upper 10%
E (Excellent)= upper 20%
H (High) 30%
HA (High Average)= upper 40%
A (Average)= middle
LA (Low Average)= lower 40%
L (Low)= lower 30%
P (Poor)= lower 20%
VP (Very Poor)= lower 10%

YOU MAY CONTACT YOUR ESO FOR DATA USED FOR YOUR MULTIPLE COMPUTATION

209.391

Figure 1-4.—Profile analysis form.

EDUCATIONAL SERVICES OFFICER

One of the officers at your ship or station has been designated as the Educational Services Officer (ESO). The office of the ESO will be your point of contact for many of your educational and training needs. When you need a Rate Training Manual, a Basic Manual, or wish to order a Nonresident Career Course, this office will accommodate you.

The ESO office is provided each year with the QUAL/BIB sheets for each rating. These sheets indicate the latest occupational standards and bibliography for your rating and are for your personal use in preparing for advancement.

NOTE: You should check with your ESO to make certain that there have been no changes to the occupational standards as indicated by the latest change to NAVPERS 18068, or to the bibliography as indicated in the latest revision to NAVEDTRA 10052.

The ESO office also provides numerous other services of which you should avail yourself. It is to the advantage of each person in the Navy to utilize to the fullest extent the services provided by the ESO.

TRAINING PETTY OFFICER

A petty officer in your unit (squadron, station, division, department, or ship) has been designated the Training Petty Officer. He usually organizes and supervises the training for advancement in rating for the unit, while the petty officer under whom you work organizes and supervises the on-the-job training. A part of the Training Petty Officer's duties is to arrange for instructors and meeting places and set the time for lectures. He may have manuals you need to study for the advancement examination; if he does not have the material available, he will know where you can get it. He should be a big help to you in your program to become qualified for the next higher rate and well prepared for the advancement examination.

CHAPTER 2

PRESSURE

Taking weather observations is one of the primary duties of the Aerographer's Mate 3 & 2. Since life, property, and successful military operations depend on reliable forecasts, it is essential that the forecasts are based on accurate observations. Therefore, it requires that the Aeorgrapher's Mate be able to define the various weather elements, know the equipment utilized to sense, detect, and measure these elements, including the proper safety and maintenance procedures of each, along with the correct procedures and form to be used in recording the elements.

The treatment of observational procedures in this manual begins by dividing meteorological instruments into chapters according to the elements being sensed or detected or measured (Chapters 2 through 6). These chapters are followed by two chapters on communications and office equipment. (Chapters 7 & 8). Chapter 9, specialized meteorological equipment, concludes these chapters and treats with that equipment which is only used in limited numbers or for special observational requirements.

PRESSURE

Pressure is of vital interest to meteorologists. This section is designed to give you various pressure definitions, observation and computational procedures, and their proper entries on the MF1-10 (NWSC 3140/7) and NWSC Form 3140/8.

DEFINITIONS

Pressure definitions are as follows:

1. Atmospheric pressure. The pressure exerted by the atmosphere at a given point.
2. Station pressure. The atmospheric pressure at the assigned station elevation.
3. Station elevation. The officially designated height above sea level to which station pressure pertains.
4. Sea-level pressure. A pressure value obtained by the theoretical reduction of station pressure to sea level.
5. Altimeter setting. That pressure value to which an aircraft altimeter scale is set so that it will indicate the altitude above mean sea level of an aircraft on the ground at the location for which the value was determined.
6. Pressure change. The net difference between the barometric pressure at the beginning and ending of a specified interval of time, usually the 3-hour period preceding an observation.
7. Pressure characteristic. The pattern of the pressure change, as would have been indicated by a barograph trace, during the specified period of time, usually the 3-hour period preceding an observation.
8. Pressure tendency. The pressure characteristic and amount of pressure change during a specified period of time, usually the 3-hour period preceding an observation.
9. Pressure altitude. The altitude, in the standard atmosphere, at which a given pressure will be observed. It is the indicated altitude of a pressure altimeter at an altitude setting of 29.92 inches of mercury and is therefore the indicated altitude above the 29.92 constant-pressure surface.
10. Density altitude. The pressure altitude corrected for temperature deviations from the standard atmosphere.

DETERMINING PRESSURES

Weather observations require observations of station pressure, sea level pressure, and altimeter setting. Also required at certain standard times is the pressure tendency.

When properly calibrated and compared, the precision aneroid barometer is normally used for observations of station pressure. The microbarograph will be used only for "tendency." The mercurial barometer is then used mainly for comparison of the readings from the aneroid barometer. Refer to Federal Meteorological Handbook No. 1 (FMH-1) for instrument priority in determining station pressure.

To properly obtain a correct reading from the aneroid barometer the observer should follow the next three steps:

1. Reduce the effect of friction by tapping the face of the instrument lightly with your finger.
2. Read the scale at the pointer, straight on, not left or right, to avoid the angle of parallax which will cause high or low reading, to the nearest 0.005 inch or 0.1 millibar, estimating any values that fall between these graduations.
3. Apply all posted corrections to the instrument that have been predetermined from instructions in FMH-1, chapter A12, Operations of Equipment.

If your station has an AN/GMQ-29() installed, all that is required to obtain the pressure reading is to observe the digital readings on the display module of the unit. The pressure readings are derived from the BAROMETRIC PRESSURE SENSOR ML-642/GMQ-29, which responds to absolute pressure by means of a pressure sensitive capacitor. Pressure changes cause the capacitor to change value and to, in turn, vary frequency of a precision oscillator. A discriminator converts the pressure-related frequency into a direct-current voltage, on a scale of 0.00 Volts Direct Current (VDC) to +10VDC for an associated pressure range of 800.0 to 1100.0 millibars.

To obtain station pressure from the mercurial barometer, the following general procedures are normally used:

1. Read the attached thermometer to the nearest 0.5°.
2. Turn the thumbscrew at the bottom of the barometer to raise the mercury level until its surface just touches the tip of the ivory point (i.e., until the tip coincides with its image in the mercury). If a dimple forms on the surface, the cistern has been raised too far.
3. Lightly tap the metal portion of the cistern and the metal casing near the top of the mercury column.
4. Then raise the vernier slide until its lower edge is above the mercury column, after which lower the vernier slide gradually until the bottom edge is tangent to the meniscus of the mercury. With proper adjustment, you see two triangular white sections on either side of the point of contact.
5. Lower the mercury about 1/4 inch from the ivory point; do not change the setting of the vernier.
6. Read the attached scale on the left of the mercury column. Note the value of the division which is immediately below the zero mark of the vernier. It is graduated to the nearest five-hundredths of an inch. Now read upward and find the first mark on the vernier scale that coincides with a mark on the fixed scale and read the vernier to the nearest two-thousandths of an inch. Estimate the final thousandths, if any. The observed reading is accurate to the nearest thousandth of an inch. Add this vernier reading to the figure noted on the fixed barometer scale. The result is the observed barometric reading. (See fig. 2-1.)
7. Determine the total correction (instrument error, gravity, and temperature) and add it algebraically to the observed barometric reading to obtain the station pressure.

Weather offices should be equipped with all of the necessary corrections; if not, they can be found in the Smithsonian Meteorological Tables. A copy of these tables is in every weather office.

For a more detailed description of determining station pressure from mercurial barometers, refer to the Manual of Barometry FMH-8 Vol. 1 (NA50-10-510).

Sea Level Pressure

Sea level pressure is obtained by several methods, depending on the elevation of the station. It is computed, recorded, and transmitted for each hourly, 3-hourly, and 6-hourly observation. Stations with low elevations above sea level (or below sea level) use a constant reduction factor. Stations for which a constant reduction factor has not been established use Meteorological Pressure Reduction Computer CP-402/UM and a table of pressure reduction ratio, "r", which is described later in this chapter.

CONSTANT ADDITIVE CORRECTION.—Most naval shore activities and all ships can reduce station pressure to sea level pressure by a

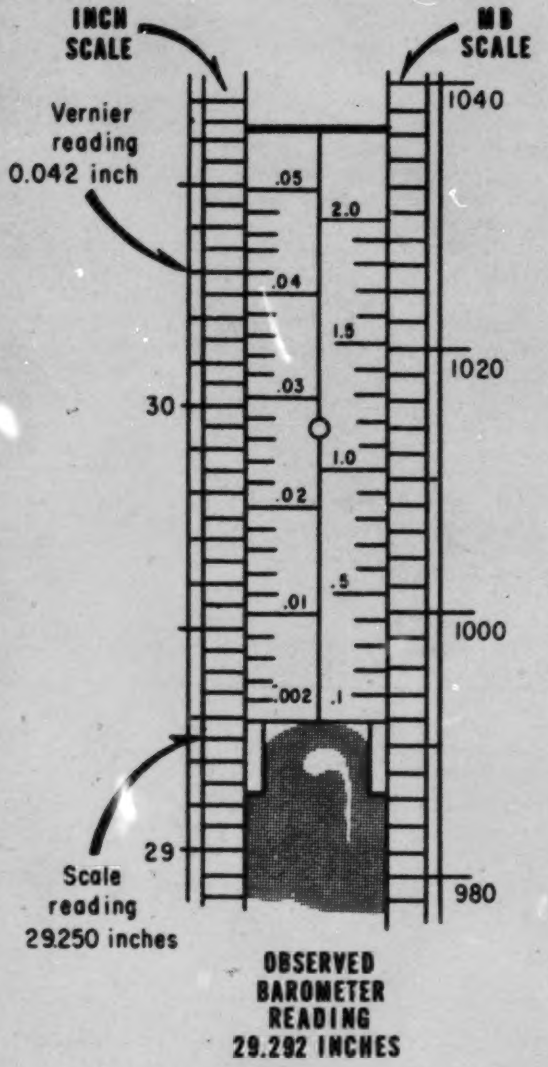

INCH SCALE
MB SCALE
Vernier reading 0.042 inch
.05
.04
.03
.02
.01
.002
2.0
1.5
1.0
.5
.1
1040
1020
1000
980
30
29
Scale reading 29.250 inches
OBSERVED BAROMETER READING 29.292 INCHES

Figure 2-1.—Reading the Mercurial barometer.

constant additive correction. This constant additive correction is a permanent value to be added (algebraically) to the station pressure. Each station authorized to use the constant additive correction has been assigned this value by Naval Weather Service Detachment (NWSD), Asheville, N.C.

For instance, Naval Station Midway Island would add +0.034 to the station pressure in order to obtain sea level pressure.

REDUCTION BY COMPUTER.—Shore activities not authorized to use the constant additive correction, use Meteorological Pressure Reduction Computer CP-402/UM, together with the tables of "r" values.

The "r" value is a ratio of sea level pressure to station pressure for each degree of temperature. As this ratio is always equal to or greater than unity (1), the figure "1" preceding the decimal point has been omitted from the "r" tables. No interpolation is necessary when using the table of "r" values.

Complete instructions for the use of the computer are printed on the computer. Instructions for the "r" tables are given with the tables. The "r" table must be appropriate for the station elevation and location. To obtain "r" tables, a request should be sent to the Naval Weather Service Detachment (NWSD) Asheville, North Carolina 28801.

Altimeter Setting

Altimeter settings are computed for all observations with the exception of a single element special. They are recomputed when necessary to meet local requirements or upon request. Values are determined at stations equipped with a mercurial barometer that is used routinely as a comparison standard. Barometric instruments used to obtain altimeter settings include precision aneroid barometers, barographs, mercurial barometers, and altimeter setting indicators.

Careless and hasty altimeter settings contribute to potential accidents of aircraft; therefore, use extreme care in computing them—as you would in all phases of weather observations.

Altimeter settings may be computed by use of the Pressure Reduction Computer (CP-402/UM), specially prepared altimeter-setting tables, or in the case of ships, by applying a constant correction to barometric data.

Stations authorized to use the pressure reduction computer use the computer to determine the altimeter setting from station pressure. Instructions for these steps are printed on the computer. Basically, the operation consists of setting the station pressure on one index and reading the altimeter setting on another scale.

Most stations have tables of altimeter settings already prepared. Some stations may have tables that you enter with the station pressure (rounded off) and emerge with the altimeter setting. Other stations may have tables which require you to make the 0.01 correction to station pressure and then enter the table. Refer to FMH No. 1 for the use of altimeter-setting tables. The altimeter setting is determined for all aviation observations; it is redetermined upon request, and when necessary to meet locally established requirements.

Pressure Tendency

The barometric pressure tendency comprises the net change within a specified time and the characteristic of the change during that time. Pressure tendencies are determined at stations equipped with a microbarograph. Stations not equipped with a barograph will utilize the trend of the altimeter settings entered in column 12 of MF1-10 or column 15 of NWSC 3140/8 to determine the pressure tendency. The pressure tendency is determined for the full 3-hour period ending at the actual time of the observation.

Classify the characteristic of the barograph trace for the 3-hour period, using the code figures prescribed in FMH-1 table A3-9, corresponding to the same general pattern. When the tendency of the observed trace is incompatible with the sign of the net change, select the tendency that is most nearly representative and still compatible with this sign.

FORMS

Several types of forms are commonly used in the recording of pressure elements. These forms are known as; MF1-10, Surface Weather Observations (Abridged for Naval Weather Use); NWSC 3140/8, Surface Weather Observations (Ship); MF1-13, Barometer Comparisons; and Barograms that are appropriate to the barograph being used. (See appendixes, IV, V)

MF1-10 Entries

Although the following description of pressure element entries on MF1-10 is correct, it is brief. The Aerographer's Mate should refer to the FMH-1 for a more complete and detailed description of the proper procedures.

SEA LEVEL PRESSURE (COL. 6).—Sea level pressure is entered in tens, units, and tenths of millibars. If the pressure is estimated, prefix the value with an "E". To obtain the sea level pressure value, take the station pressure (col. 17) and reduce this value to sea level by use of a computer, constant, or table.

ALTIMETER SETTING (COL. 12).—The altimeter setting is entered in column 12 in units, tenths, and hundredths of an inch, omitting the decimal point. An altimeter setting of 29.98 inches is logged as 998. Altimeter settings determined from pressure instruments of doubtful accuracy or which are not routinely compared with a mercurial barometer are prefixed with an "E". Compute the altimeter setting value from the station pressure (col. 17) by using a computer, constant, or table.

MANDATORY REMARKS (COL. 13).—These remarks include the pressure tendency at 3-hour intervals. Other data includes pressure that is rapidly rising or falling; barogram "V"; unsteady pressure; and pressure jumps.

STATION PRESSURE (COL. 17).—Enter station pressure to the nearest 0.005 inch in column 17.

NWSC 3140/8

SEA LEVEL PRESSURE (COL. 9).—Enter sea level pressure in the same manner as that for MF1-10.

Aboard Navy ships, sea level pressure is obtained by adding a constant pressure-reduction factor to the station pressure as entered in column 23. This constant is the product obtained by multiplying the height (in feet) of the precision aneroid barometer above the loadline by either 0.001 inch or 0.037 mb, depending on the markings of the barometer.

ALTIMETER SETTING (COL. 15).—Enter the altimeter setting in the same manner as on MF1-10. Ordinarily, altimeter settings are computed and entered only on naval vessels from which aircraft are operated.

Shipboard altimeter settings are computed by converting sea level pressure to inches. When estimated, prefix the setting with an "E". Some ships may have altimeter setting indicators which are direct-reading instruments requiring only instrument error corrections.

REMARKS (COL. 16).—Enter appropriate remarks in the same manner as in column 13 of MF1-10. The major exception to this is that additive data referred to in sections covering land station observations are not entered aboard ships. For more details, see FMH No. 1.

STATION PRESSURE (COL. 23).—Station pressure aboard ship is determined from precision aneroid barometers. It is entered in the same manner as in column 17 on MF1-10.

When rolling of the ship causes the indicator on the aneroid barometer to oscillate, the mean position is used for the station pressure.

SUMMARY OF THE DAY (COL. 57).—Enter the lowest pressure recorded in the 24-hour period in millibars and tenths.

Barometer Comparisons, MF1-13

To ensure that proper and correct pressure data is being computed, especially with respect to altimeter settings, the aneroid barometer will be routinely compared with the mercurial barometer to determine that suitable corrections are being applied to the aneroid barometer.

Once installed and operationally accepted as a reliable barometer, each weather office should make two comparisons, at 6-hourly intervals on the same day of each week. These readings should be entered on MF1-13, in accordance with the instructions printed on the back of the form. For further information on the comparisons and use of the computed comparisons in relation to the unreliable performance of an aneroid barometer, refer to FMH-1, chapter A12.

Barograms

Microbarograph charts should be handled in the following manner:

1. Before placing a chart on the barograph, use a typewriter, rubber stamp, or pen and ink to enter the following data:

a. In the spaces provided, enter the name of the station and its type (NAS, FWC, etc.), state, meridian of local standard time (15th, 90th, etc.), and elevation of the station (H_p) to the nearest foot. Where provision is not made for the H_p entry, identify the value with the prefix Hp =. Aboard ship, enter the name of the ship and route "from - to."

b. In the spaces provided, or above the appropriate noontime lines, enter the date of beginning and ending of the trace.

c. Immediately preceding the printed figures along the first and last time arcs, enter the appropriate figures to indicate the chart range (e.g., 28 preceding the printed 00 on the 28.00 inch line).

d. In the spaces provided, or near the point where trace will begin, enter "ON:" and the time to the nearest minute (LST at shore stations; GMT aboard ship) and the current station pressure.

2. After adjustments or removal of a completed microbarograph chart, use the following procedure:

a. Enter the time of each adjustment, and an arrow to indicate the point of adjustment.

b. In the spaces provided, or near the end of the trace, enter "OFF:" and the time to the nearest minute and the current station pressure.

c. Enter the appropriate corrections above the time-check lines. The pen of the marine barograph should be touched lightly once each day at the 1200 GMT observation, and the correction to the marine barograph reading determined by comparing the corrected aneroid barometer reading with the microbarograph reading. These corrections are entered at the corresponding points on the barogram after the latter has been removed from the cylinder. In addition, aboard ship, the position is entered each day beside the 1200 GMT time-check.

d. When adjustment for pressure is made, enter the current station pressure and corrections applying to both the preceding and following record (i.e., -.055/0) near the break in the trace.

3. Change charts at 6-hourly times (0000, 0600 GMT, etc.) closest to noon LST on the 1st, 5th, 9th, etc., day of the month.

4. Microbarograph charts are forwarded to Naval Weather Service Detachment, Asheville, N.C., in accordance with procedures listed in chapter 11 of this training manual.

BAROGRAPHS

OPEN-SCALE BAROGRAPH (ML-3)

The open-scale barograph (ML-3) is often referred to as the microbarograph, just as the marine barograph is. This instrument has been replaced by the marine barograph, but many are still in use at shore stations. Instructions for their operation and maintenance are contained in the appropriate equipment manuals.

MARINE BAROGRAPH

The purpose of the marine barograph is to register and record the atmospheric or barometric pressure. Because of the magnified scale, high sensitivity, and accurate temperature compensation, it is often referred to as a microbarograph. The instrument is designed to maintain its precision through the varied and exacting conditions encountered in marine use. Its record is neither interrupted nor rendered inaccurate by pitch, roll, or vibration of the ship. An adjustable, grease-filled damping cylinder provides a means of preventing rise and fall of the ship from causing a corresponding wavy trace on this chart. The unit, as seen in figure 2-2 is quite portable and can record pressure either in its immediate vicinity or at some remote external point while located within a pressurized cabin system. This barograph has a total usable range of 170 mb (915 to 1085 mb) over which it has been calibrated and temperature-compensated.

The airtight case locks to the base by means of two latches. When it is in place, a flexible rubber tube running to the hose connector from a remote source provides the means by which "outside" readings are recorded independently of the cabin pressure surrounding the instrument.

The marine barograph has three principal sections within the gasketed case: the chart drive assembly, the element assembly, and the pen shaft mechanism assembly. The last two sections are of no interest to the regular user-observer of the instrument.

The chart drive assembly consists of a chart drive mechanism, a chart cylinder, a chart, and a chart clip. The chart drive mechanism is an 8-day, spring-wound clock with antibacklash gears and a self-contained lever for winding. The removable cylinder is driven at the rate of one revolution in 108 hours (4 1/2 days) through additional antibacklash gears. As a result, vibration and shock do not make the chart record irregularly as a result of play in the cylinder drive system. Inside the cylinder top is a knurled nut which permits removal of the cylinder for winding the clock. The chart is held in place by a chart clip.

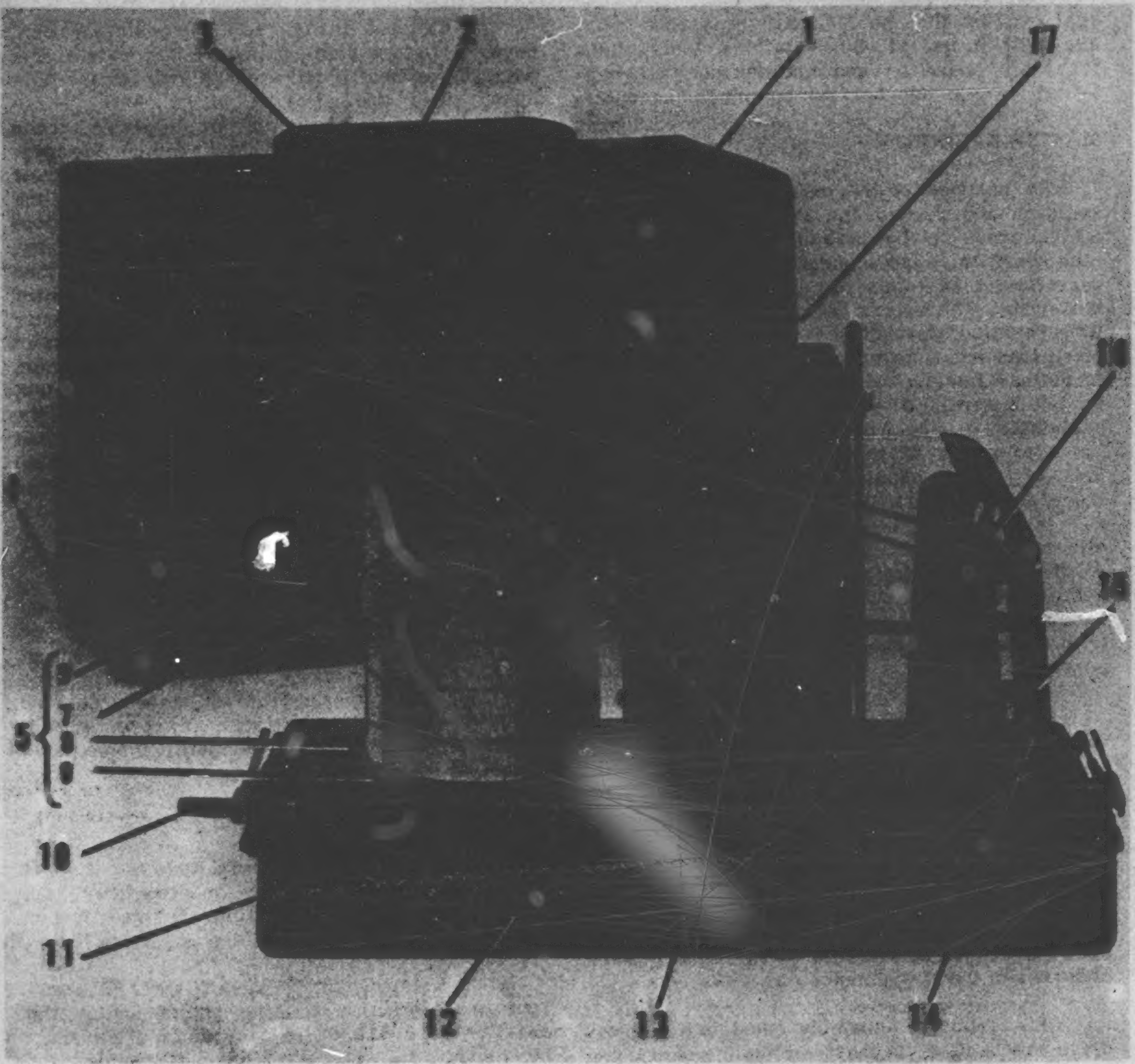
The element assembly is the center section, covered by the element cover. It consists of a pair of vertically mounted bellows whose outboard ends are secured to brackets. These brackets are moved apart or together by the adjustment knob on top for zeroing the pen position. The inboard ends are flexibly connected to a beam which moves as pressure variations affect the bellows. Between the two flexible connections is a temperature compensation device, which is adjusted to correct temperature change errors occurring throughout the element assembly.

The pen shaft mechanism is the right-hand section under the mechanism shield. The shield and its spacers are to protect the mechanism from damage as the case is removed or replaced. The mechanism includes range and linearity adjustments, the damping device, and the temperature compensating lever which compensates for changes in temperature. The damping device is a set of cylinders with a thin layer of special fluid. The damping and spring loading make it possible for the barograph to be subject to tilting up to 22 1/2° in any direction and not vary more than ±0.3 mb from the true reading. Normal accuracy is within ±0.3 mb of true pressure. Also, the instrument may be carried about by its handle without any preparation. If rougher treatment is anticipated, the pen arm should be secured.

Operation

This barograph needs very little attention. It records barometric pressure on a 108-hour chart and can be read at any time by interpolation to within one- to two-tenths of a millibar.

WINDING AND CHART CHANGING.—The correct procedure for winding and changing the chart is as follows: Lift the pen from the chart by means of the pen lifter and remove the cylinder. Every time a chart is changed, the clock should be wound; approximately 8 pulls of the lever is enough. Wrap a chart around the cylinder so the tab end is covered and the chart is held in place firmly against the bottom flange of the cylinder and replace the chart clip. Install the cylinder carefully in place until the antibacklash gear teeth engage. By rotating the cylinder, set the pen to indicate the correct time. Check to see if the pen has sufficient ink (about one-half full), then lower the pen and replace the case. If the ink should



1. Case.
2. Plastic sheet.
3. Handle.
4. Latch.
5. Chart drive assembly.
6. Chart clip.
7. Chart.
8. Chart cylinder.
9. Chart drive mechanism.
10. Hose connector.
11. Base.
12. Element assembly.
13. Element cover.
14. Mechanism shield.
15. Spacer.
16. Pen shaft assembly.
17. Adjustment knob.

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Figure 2-2.–Marine barograph.

fail to feed, reopen the case and draw a piece of glossy (bond) paper through the pen nibs to start the flow.

PEN AND INK.—Very little ink is needed; a half-full pen should suffice. In fact, in damp weather the nib may appear to become fuller. This is because the instrument ink is hygroscopic and absorbs moisture. As this process continues, the trace becomes paler because of dilution. Wash and re-ink. A wide trace is caused by dust accumulated on the point, or a dull or bent point.

USE BEYOND CHART RANGE.—The normal barograph chart has a range of 965 to 1,060 mb. When approaching any extreme pressure condition which may carry the pen off the chart, turn the adjustment knob to move the pen about 40 mb away from the close edge of the chart. When the condition is passed, reset by the exact same amount and mark the affected portion of the chart accordingly.

PLASTIC SHEET WINDOW.—Use a damp cloth to clean the plastic sheet window in the case. Do not use a solvent cleaner or a dry cloth, as either can damage the plastic pane.

Maintenance

Very little maintenance is required for the marine barograph. This section covers such service, replacement, adjustment, and minor repair as may be needed and can be performed with no more than partial disassembly and not require the use of special tools or test equipment.

Under normal operating conditions this instrument should be cleaned well once a year. The element cover should be removed only to clean out any bulky dirt, cobwebs, etc. Do not wipe out this mechanism. Check the pen for wear or roughness and replace as necessary.

The chart drive mechanism should be cleaned and oiled annually. This oiling should not be attempted by Aerographer's Mates 3 or 2 unless they are properly instructed in the method of doing it.

For other troubles with the marine barograph, consult the applicable instrument handbook.

BAROMETERS

MERCURIAL BAROMETER (FORTIN)

In 1643 Torricelli, an Italian physicist, made the first crude barometer. The mercurial barometers that are used in the Navy today operate on the same principle. In the construction of the barometer, a long glass tube, open at one end and closed at the other, is filled with mercury. The open end is sealed temporarily and then placed into a basin (cistern) of mercury, after which the end is unsealed. This allows the mercury in the tube to descend, leaving a nearly perfect vacuum at the top of the closed end of the tube.

When the atmospheric pressure is increased, the mercury in the cistern is forced into the glass tube. As the atmospheric pressure is decreased, the mercury in the tube flows into the cistern. The height of the mercury column in the tube is therefore a measure of the air pressure. (See fig. 2-3.)

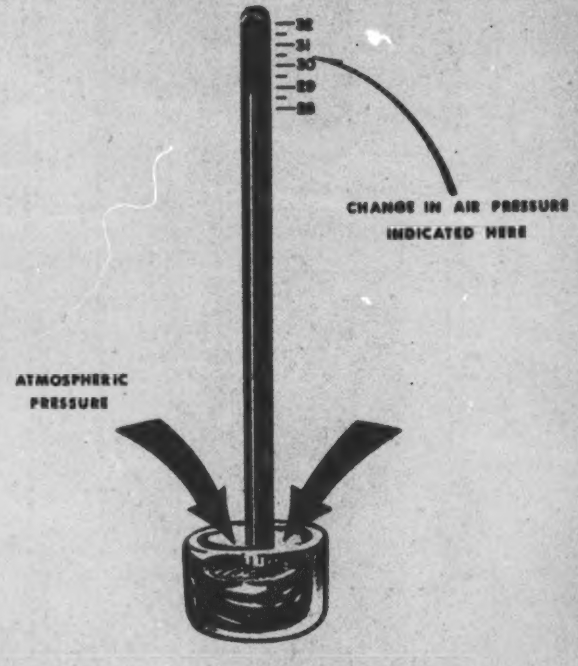

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Figure 2-3.—Principle of the Mercurial barometer.

The mercurial barometer now being issued to naval weather units ashore is the adjustable cistern (Fortin) type, ML-512/GM with mounting case ML-48( ). See figure 2-4 for an illustration of a Fortin barometer with mounting case.

Description

The mercurial barometer, ML-512/GM, consists principally of a column of mercury in a glass tube enclosed in a brass casing, a mercury cistern, and scales for determining the height of the mercury.

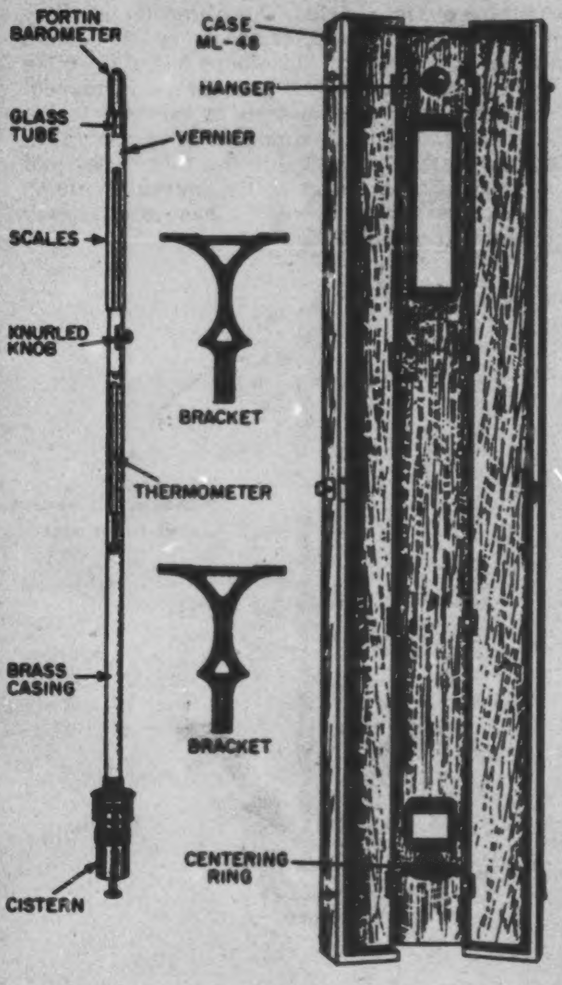

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Figure 2-4.—Fortin barometer with mounting case.

GLASS TUBE AND BRASS CASING.—The glass tube is 34 to 35 inches long, about 0.25 inch in internal diameter, and clear and free from optical defects. The top of the glass tube is sealed, filled with mercury except at its upper end (this end is evacuated), and the open bottom end is immersed in a reservoir of mercury in the cistern.

The glass tube is supported vertically in the center of a tubular brass casing. The top of this casing is provided with a brass swivel ring by which the instrument is supported in use. This brass casing encloses and protects the glass tube, carries the scales by which the height of the mercury column is determined, provides a track for the movable vernier, and provides a mounting base for the thermometer.

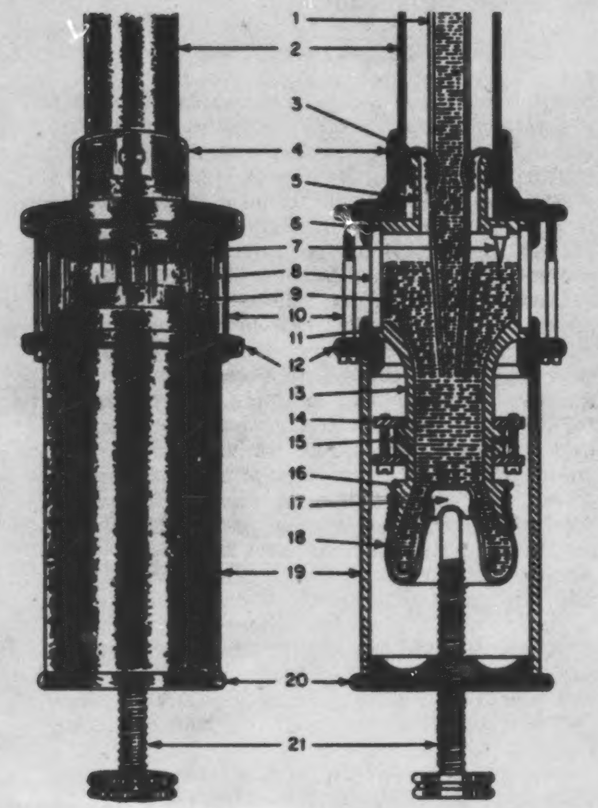
The glass tube is joined to the cistern by a piece of soft kid leather which is folded in a special manner, tied securely to the constricted portion of the tube, and then tied to the top of the mercury cistern.

CISTERN.—The mercury cistern (fig. 2-5) consists of a small flanged boxwood cylinder (5), a short glass cylinder (8), two curved cylinders (13 and 16) made of boxwood, and a kid leather bag (18). The ivory point (7) projects downward from the roof of the cistern. The mercury cistern is enclosed in a metal cistern housing (19) that is closed by a screwcap (20) at the bottom which carries the adjusting screw (21). Prior to each observation, this adjusting screw is used to raise or lower the level of mercury in the cistern so that the ivory point just perceptibly touches the surface of the mercury.

The leather joint and leather bag are porous to air, but impervious to mercury. This permits the cistern air pressure to be identical with that outside, but prevents mercury leakage.

In the event mercury is spilled either by leakage or by breakage, it is important to well ventilate the room and clean up the spilled mercury promptly. When mercury is exposed to air or heat it will give off mercury fumes which can be harmful to health. These fumes may even be fatal if breathed in sufficient quantity.

MOUNTING CASE.—The mounting case, ML-48( ), is a rectangular box of mahogany or plywood. The cover of this case is split longitudinally through the center, and each side is hinged to



1. Glass tube.
2. Brass casing.
3. Leather joint.
4. Top flange.
5. Flanged cylinder.
6. Leather gasket.
7. Ivory point.
8. Glass cylinder.
9. Mercury.
10. Long screws.
11. Leather gaskets.
12. Lower flange.
13. Upper curved cylinder.
14. Split-ring clamp.
15. Leather gasket.
16. Lower curved cylinder.
17. Wooden bearing.
18. Leather bag.
19. Cistern housing.
20. Screwcap.
21. Adjusting screw.

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Figure 2-5.—Exterior and cross section view of a Fortin barometer cistern.

the back. With the cover open, the barometer is completely exposed, so that all parts are accessible and adjustments can be made easily. A metal hanger inside the case near the top and a centering ring near the bottom provide means for suspending the barometer. Two openings in the back of the case are fitted with white opal glass or heavily pigmented white Plexiglas to facilitate reading the scales and observing the cistern level. Two brackets are provided for mounting the case on a wall, post, or other suitable vertical surfaces.

SCALES.—The Fortin barometer has two scales. One is the stationary scale, which allows reading of the barometer to the nearest 0.05 of an inch (also graduated in millibars, but not read). The other is an adjustable scale, called the vernier, which is graduated to allow reading the barometer without interpolation to the nearest 0.002 of an inch.

Maintenance

Preventive maintenance for the Fortin barometer consists largely of cleaning, minor adjustments, and daily inspections. These inspections include checking for cracks in the glass tube or cylinder; damage to the wooden case; loose screws in the case brackets, hanger, and centering ring of the case; and condition of the mercury column. If a cracked tube, a mercury leakage, or other damage that may affect the accuracy of the instrument is discovered, it becomes necessary to request a replacement barometer and to ship the defective barometer to NAS, Norfolk or NAS, Alameda for overhaul.

The barometer and case should be kept clean by wiping with a soft, clean cloth. Occasionally, the scales may be wiped clean and a thin coat of high-grade clock or instrument oil applied. Do not use a commercial polish on the scales or use heavy pressure when wiping them.

The Aerographer's Mate may change broken thermometers and repair damage to the wooden case. For complete information on the maintenance of the ML-512/GM, refer to NW 50-30ML512-1.

ANEROID BAROMETERS

Mercurial barometers are quite accurate, but they are expensive and are not easily transported. For numerous practical purposes they are replaced or supplemented by a mechanical instrument known as the aneroid barometer. The term "aneroid" means without fluid. The aneroid barometer, then, is a fluidless barometer, utilizing the change in shape of an evacuated metal cell to measure variations in atmospheric pressure.

The aneroid barometer gets its name from the pressure-sensitive element used in the instrument. It is an aneroid, which is a thin-walled metal capsule or cell, sometimes called a diaphragm, that has been either partially or completely evacuated of air. The aneroid is usually made of beryllium copper or phosphor bronze. Most aneroid cells in the currently used aneroid barometers are self-supporting, and do not require external or internal springs to prevent the crushing of the cell walls by atmospheric pressure.

In a common type of single aneroid cell barometer, the top of the evacuated cell is secured to a suitable linkage which transmits the motion of the aneroid to an index hand or pointer, which indicates the pressure. (See fig. 2-6.)

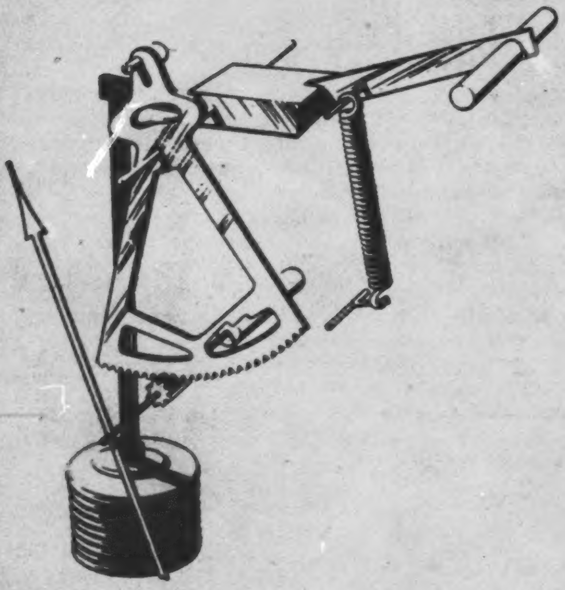

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Figure 2-6.—Simple diagram of the aneroid barometer.

Precision Aneroid Barometer (ML-448/UM)

The Precision Aneroid Barometer (ML-448/UM) is used aboard ship and at land stations.

Of precision design and manufacture, the precision aneroid barometer is constructed to accurately indicate atmospheric pressure in millibars or inches of mercury. (See fig. 2-7.)

The pressure element of the precision aneroid is a Sylphon cell, which consists of a bellows-shaped metal cell having an internal spring to provide pressure calibration. This element is sensitive to minute variations in atmospheric pressure. The Sylphon cell is connected to an indicating pointer or index by means of a quadrant gear and lever system in such a manner that the movement of the cell, for a given change in atmospheric pressure, is greatly magnified by the linkage. This pressure variation is then transmitted to the index hand or pointer with a minimum of friction in the moving parts. The instrument has a range from 910 to 1060 mb, and it is accurate to 0.67 mb. Outside normal sea level pressure range it is still accurate to within 1.0 mb.

The precision aneroid barometer is compensated for temperature changes; therefore, the indicated readings require no temperature corrections as are required for the mercurial barometer.

Aneroid barometers utilize spring pressure to balance the effect of the air pressure on the Sylphon cell. Therefore, no corrections for effect of latitude (gravity) need be applied.

The pressure element, dial, and linkage are mounted on a sturdy metal frame that, in turn, is shock-spring suspended from the aneroid case. This spring suspension minimizes the effect of jars or shocks that would otherwise affect the linkage and index setting of the barometer.

A screwdriver adjustment, located at the base of the Sylphon cell, is provided to make adjustments to the pressure readings of the instrument.

The precision aneroid barometer, when properly calibrated and set to station pressure, is used for observational purposes in lieu of the mercurial barometer.

After the precision aneroid barometer is installed in a permanent location, a series of comparative readings are taken. These comparative readings are the differences between the station pressure taken from the aneroid barometer and the station pressure from the

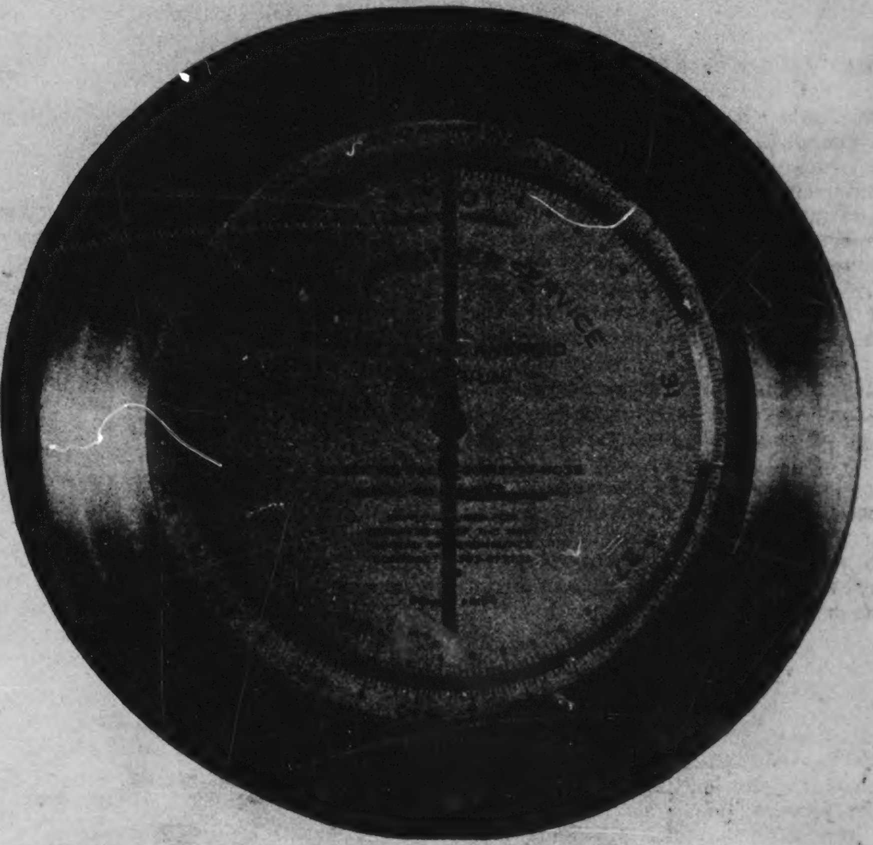

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Figure 2-7.—Precision aneroid barometer (ML-448/UM).

mercurial barometer. These differences are logged, and the algebraic mean is computed to determine an acceptable instrument correction. This correction is then posted on or near the instrument and applied to subsequent station pressure readings. Procedures for computing an acceptable precision aneroid barometer correction may be found in the Manual of Barometry or FMH No. 1, chapter A-12.

Shipboard aneroid barometers should be frequently checked for accuracy with a mercurial barometer at a Naval Weather Service unit ashore. Pressure should be reduced to sea level when compared barometers are not at the same elevation (to the nearest foot). In the comparison, care should be taken that the comparative readings are made simultaneously and during a period when the pressure tendency is steady.

When adjusting the setting of the aneroid barometer, use a small screwdriver and remove one-half of the apparent error on the first adjustment. Tap the case lightly to permit the linkage and index hand to settle to the new setting. Obtain a current station pressure from a corrected reading of the mercurial barometer and note the amount of remaining error in the aneroid. Again adjust to remove one-half of the remaining error, tap the case, and allow the hand and linkage to settle. Do not attempt to adjust for any error less than 0.5 mb. A field maintenance technician may adjust a precision aneroid to a correction of zero.

Maintenance

The exterior of the case should be dusted whenever required, and the dial window should be wiped with a clean damp cloth if necessary. Inspect the general physical appearance of the instrument. A cracked dial window, dents, bends, and other external physical damage probably indicate a need for overhaul of the instrument. Sufficient impact to cause external damage is usually sufficient to render the instrument inoperative or of suspect accuracy.

No repair, parts replacement, or lubrication are to be attempted at the observer's maintenance level.

In mounting the aneroid barometer, keep it away from areas where it might be exposed to sudden shocks or rapid thermal changes, but place it in an area easily reached by the observer. Before each reading, tap the case slightly to remove the drag effects of linkage friction. To minimize the effects of vibration on shore stations, and to minimize the effects of pitch, roll, and vibration in ships, the precision aneroid barometer should be shock-mounted.

ALTIMETERS

The Aerographer should not underrate the importance of the altimeter. Particularly important is the altimeter setting which ensures that the pilot always has a correct reading available to him. Many aircraft accidents may have been caused by a faulty altimeter setting. Today, three types of altimeters are in general use—the pressure altimeter, radio altimeter, and the radar altimeter, all of which are briefly discussed in the following paragraphs.

PRESSURE ALTIMETER

The pressure altimeter is primarily an aneroid barometer calibrated to indicate altitude in feet instead of units of pressure. The pressure altimeter reads accurately only in a standard atmosphere and when the correct altimeter setting is used. Since standard conditions seldom (if ever) exist, the altimeter reading usually requires correction. It will indicate 10,000 feet when the pressure is 697 millibars, whether or not the altitude is actually 10,000 feet.

The altimeter is generally corrected to read zero at sea level. A procedure used in aircraft on the ground is to set the altimeter reading to the elevation of the airfield. The altimeter then reads the altitude above sea level and the Kollsman window indicates the current altimeter setting. (See fig. 2-8.)

Altimeter Errors Due to Change in Surface Pressure

The atmospheric pressure frequently differs at the point of landing from that of takeoff; therefore, an altimeter correctly set at takeoff may be considerably in error at the time of landing. Altimeter settings are obtained in flight by radio from navigational aids with voice facilities. Otherwise, the expected altimeter setting for landing should be obtained by the pilot before takeoff.

To illustrate this point, figure 2-9 shows the pattern of isobars in a cross section of the atmosphere from New Orleans, Louisiana, to Miami, Florida. The pressure at Miami is 1,019 millibars and the pressure at New Orleans is 1,009 millibars, a difference of 10 millibars. Assume that an aircraft takes off from Miami to fly to New Orleans at an altitude of 500 feet. A decrease in the mean sea level pressure of 10 millibars from Miami to New Orleans would

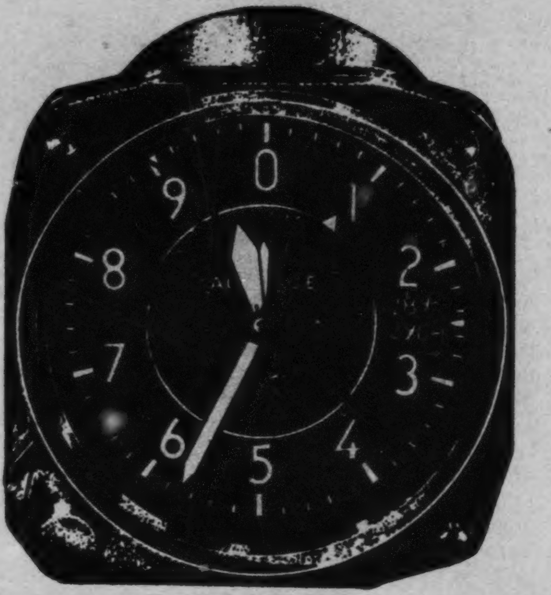

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Figure 2-8.—Pressure altimeter.

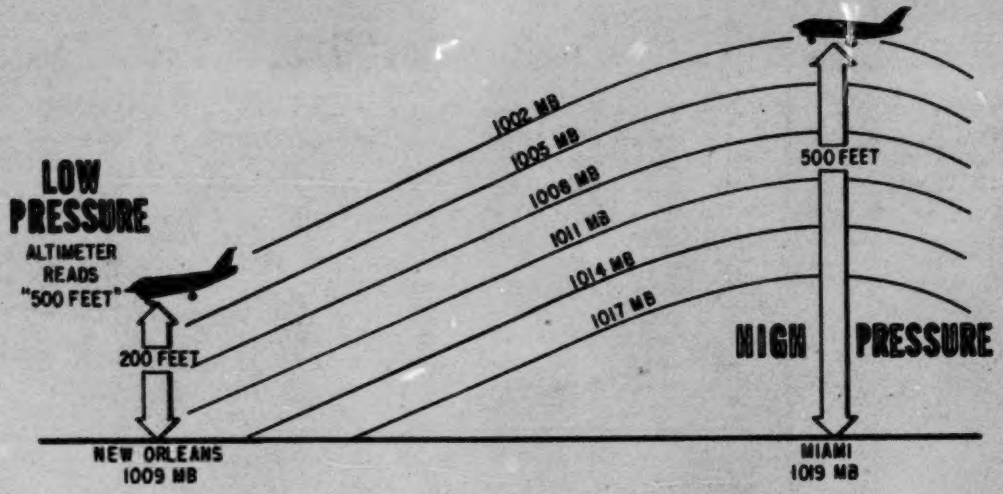

Figure 2-9.—Altimeter errors due to change in surface pressure.

cause the aircraft to gradually lose altitude; and although the altimeter indicates 500 feet, the aircraft would be actually flying at approximately 200 feet over New Orleans. The correct altitude can be determined by obtaining the correct altimeter setting from New Orleans, resetting the altimeter to agree with the destination adjustment. NOTE: The following relationships generally hold true up to approximately 15,000 feet: 34 millibars = 1 inch (Hg) = 1,000 feet elevation. Since 1 millibar is equal to about 30 feet below 10,000 feet altitude, a change of 10 millibars would result in an approximate error of 300 feet.

Altimeter Errors Due to Variation From Standard Temperature

Another type of altimeter error is due to nonstandard temperatures. Even though the altimeter is properly set for surface conditions, it will often be incorrect at higher levels. If the air is warmer than the standard for the flight altitude, the aircraft will be higher than the altimeter indicates; if the air is colder than standard for flight altitude, the aircraft will be lower than the altimeter indicates. (See fig. 2-10.)

RADIO ALTIMETERS

This type of altimeter transmits a signal that varies in frequency at an extremely rapid and constant rate. The receiver picks up the reflected signal in a frequency measuring device, which measures the difference in frequency between the transmitted and reflected signal at any instant. This difference generates a voltage which is linked to an indicator calibrated in feet. Radio altimeters work better over water than land because the water reflects the radio signals better.

Radio altimeters are very helpful in determining clearance from the surface. As such, they are extremely helpful in avoiding collision with the terrain. They are also useful under all instrument conditions and are essential for hurricane penetration to determine pressure levels and altimeter settings for the pressure altimeter. They are, however, not generally used for pressure-pattern or jet stream flight because their operational altitude is lower than that flown by most long-range transports.

RADAR ALTIMETERS

This type of altimeter works similar to the basic radar set in that it transmits ultra-high or super-high frequency pulses that are reflected

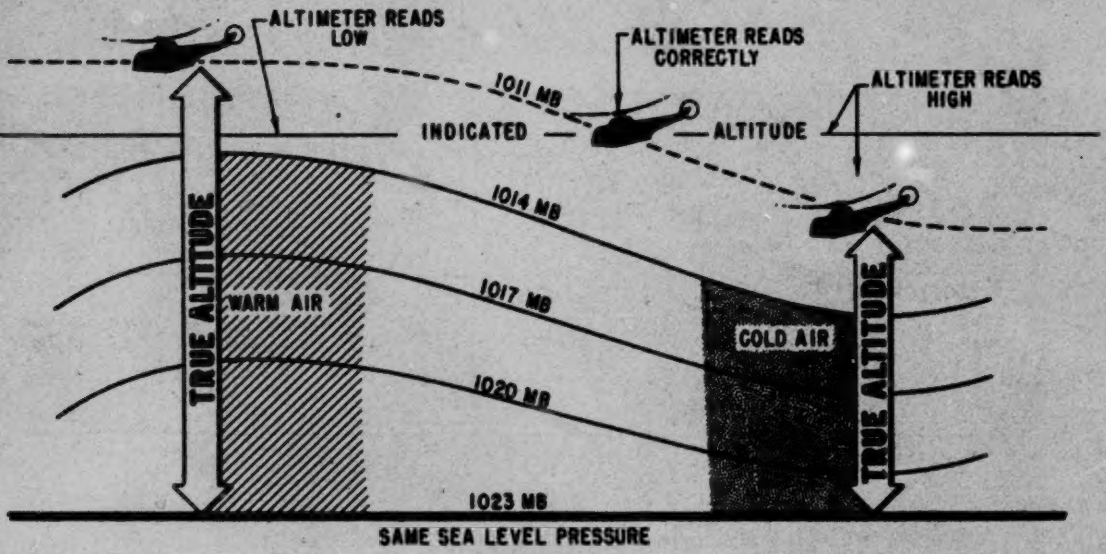
ALTIMETER READS LOW
ALTIMETER READS CORRECTLY
ALTIMETER READS HIGH
1011 MB
INDICATED
ALTITUDE
1014 MB
1017 MB
1020 MB
1023 MB
TRUE ALTITUDE
WARM AIR
COLD AIR
TRUE ALTITUDE
SAME SEA LEVEL PRESSURE

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Figure 2-10.—Altimeter errors due to nonstandard air temperatures.

back to a receiver that presents them on a calibrated cathode-ray tube.

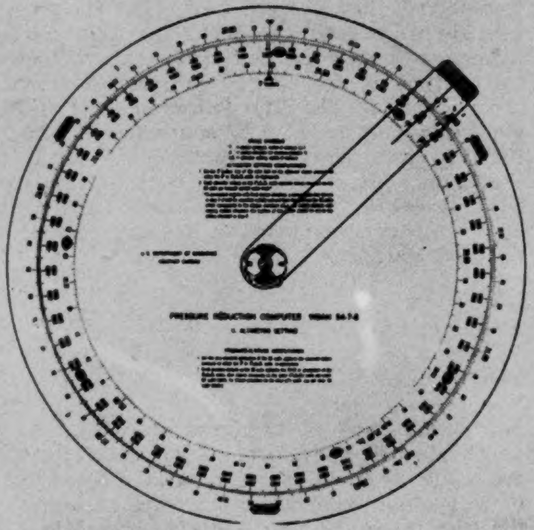
Altimeters of this type are generally used for pressure-pattern and jet-stream flying along with bombing, due to their high altitude capability.

PRESSURE COMPUTERS

To enable reporting stations to calculate pressure information in support of aviation requirements, several types of computers have been devised to meet these needs. Two of these computers, the Pressure Reduction Computer CP-402/UM, and the Density Altitude Computer CP-718/UM, are discussed in the following paragraphs.

PRESSURE REDUCTION COMPUTER CP-402/UM

The Pressure Reduction Computer, CP-402/UM, is primarily used for computing sea level pressure and altimeter settings from the observed station pressure at sites that do not have a constant reduction factor computed and authorized. It may also be used to compute



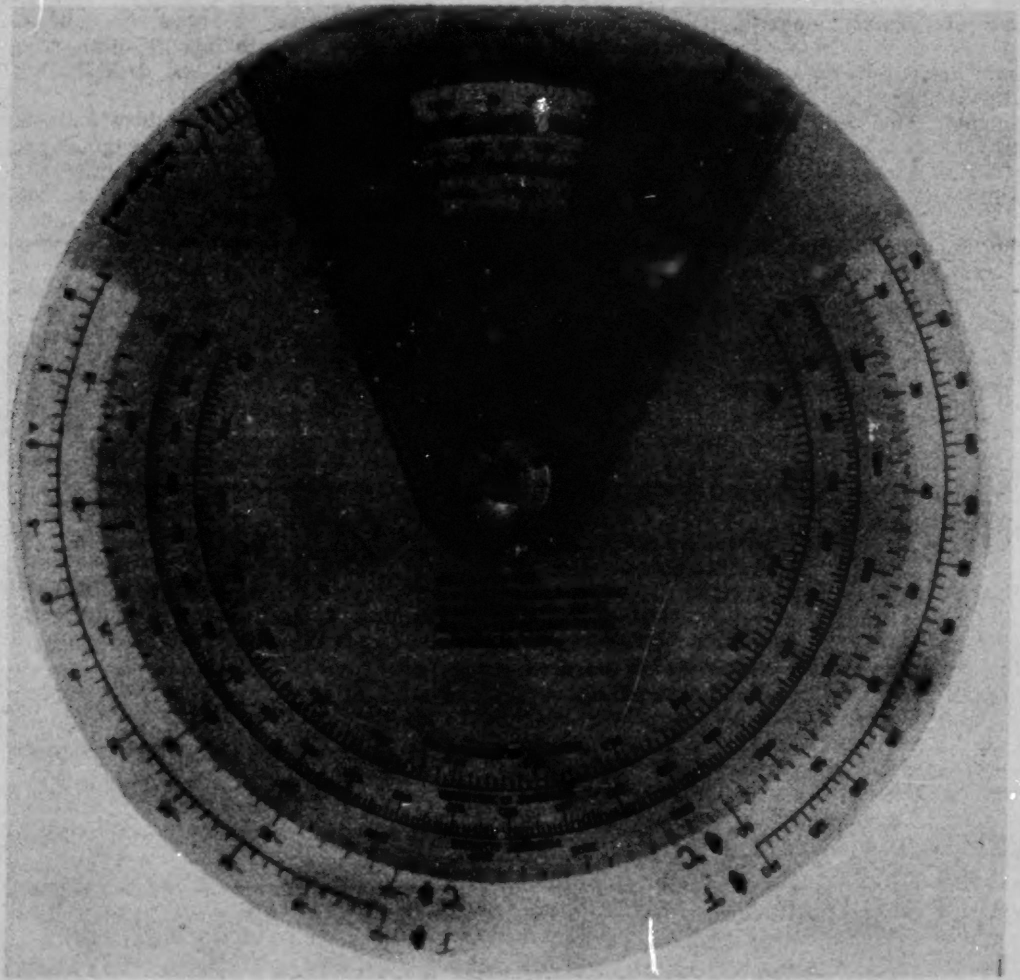
209.379

Figure 2-11.—Pressure reduction computer CP-402/UM.

pressure altitude. Both sides of the computer are used. The sea-level-pressure side of the computer has scales in millibars and in inches of mercury printed on the base plate and an "r" factor scale printed on the plastic rotor disc. The altimeter-setting/pressure-altitude side has a scale in inches of mercury on the base plate and a height scale in feet printed on the plastic rotor disc. Instructions for the operation of it are printed on the computer. (See fig. 2-11.)

DENSITY ALTITUDE COMPUTER CP-718/UM

Helicopters have their greatest lift and attain highest speeds in air of high density. Thus, pilots of these craft prefer to fly under conditions of low temperature and high pressure, since this is when the air is most dense. Pilots of jet aircraft have a great interest in the density of the air because air density not only affects



209.380

Figure 2-12.–Density altitude computer CP-718/UM.

speed, rate of climb, and fuel consumption, but also plays an important role in determining the length of runway necessary for takeoff.

The Density Altitude Computer CP-718/UM consists of two plastic or metal discs and one cursor. The bottom disc contains the temperature expressed in Celsius and Fahrenheit, while the top disc contains the pressure density, moisture correction, and dry bulb temperature scales. On the cursor is found a wet bulb temperature scale.

The computer was primarily designed to compute atmospheric density. It may, however, also be used to interconvert thermometric scales, pressure units, density ratio, vapor pressure, specific humidity, etc. The operating instructions are printed on the back of the computer. (See fig. 2-12.)

MAINTENANCE

The important points in regard to calculators, computers, and evaluators are the cleaning and storing of them. The pointers listed in this section apply to all the computers in use in the Naval Weather Service, such as the psychrometric computer, true wind computer, mixing ratio calculator, and the like.

To remove accumulations of dirt, dust, and lint from the spaces between the plates and under the cursor, draw a piece of paper through the space while applying a slight pressure to the discs or cursor. If grease or gummy deposits are present, moisten a blotter with soap and water and proceed as above. Exposed surfaces may be cleaned with a soft cloth, soap, and water. Rinse thoroughly and dry. DO NOT USE SOLVENTS.

Plastic calculators, computers, and evaluators should be returned to their original packaging preparatory to storage or shipment. If the original packaging is no longer available, an equivalent method will suffice. The items should not be stored in any atmosphere in which the temperature exceeds 140° F.

NOTE: Changes to all column numbers and entries on NWSC Form 3140/8 were received too late for inclusion in this manual. Where errors in column numbers appear, refer to the U.S. Navy Supplement to FMH #1, Chapter 13, Marine Aviation Observations for the most recent amplifying instructions.

CHAPTER 3

WIND EQUIPMENT

The usual point for taking observations is at the surface of the earth. When we refer to the weather element "wind," we are speaking of "surface wind." This chapter will deal with various types of equipment used in measuring wind, methods of observing, procedures for recording, requirements for maintenance, and wind computers. You will find a discussion on the various facets of wind, in chapters 12, 13, 14, and 15. Upper winds and their associated measuring equipments are briefly discussed in chapters 9 and 10 of this manual.

WIND

Wind is air in motion. As air in motion, the wind has four important properties of vital interest to us: direction, speed, character, and shifts. The character of the wind refers to its gustiness and the like; the shifts of the wind refer to its steadiness or unsteadiness in direction.

DEFINITIONS

Wind definitions are as follows:

1. Wind direction. Wind direction is the direction FROM which the wind is blowing. It is reported with reference to true north, and is expressed to the nearest 10 degrees or to 16 points of the compass.

2. Wind speed. Wind speed is the rate of motion of the air in a unit of time. Wind speed can therefore be measured in a number of ways. The Naval Weather Service measures the speed of the wind in knots; that is, it measures the wind in nautical miles per hour.

3. Gust. Gust is defined as rapid fluctuations in wind speed with a variation of 10 knots or more between peaks and lulls.

4. Squall. Squalls are defined as a sudden increase in wind speed of at least 15 knots and sustained at 20 knots or more for at least 1 minute. The occurrence of squalls is indicative of turbulence near the surface.

5. Peak gust. The highest instantaneous wind speed observed or recorded.

6. Wind shifts. "Wind shift" is a term applied to a change in wind direction of 45° or more which takes place in less than 15 minutes. Wind shifts are normally associated with some or all of the phenomena characteristic of a cold-frontal passage. These phenomena are:

a. Gusty winds shifting in a clockwise manner in the Northern Hemisphere and counterclockwise in the Southern Hemisphere.

b. Rapid drop in dewpoint.

c. Rapid drop in temperature.

d. Rapid rise in pressure.

e. In summer: lightning, thunder, heavy rain, and possibly hail.

f. In winter: frequent rain or snow showers.

Changes of wind direction may also result from other causes such as katabatic or foehn winds, sea breezes, and thunderstorms. In such cases, the change of direction may be gradual or abrupt, and may or may not be accompanied by significant changes of other weather elements. Wind shifts are reported when believed to be associated with frontal movement, or when considered important for the safety of aircraft operations.

7. Variable wind direction. Wind direction is considered to be variable when it fluctuates by 60° or more during the period of observation.

8. Light wind. The wind is considered to be light when the speed is six knots or less.

WIND MEASUREMENTS

There are four qualities of the wind that the observer must determine; they are wind direction, wind speed, character, and shifts. Instructions for determining these qualities of the wind are contained in the following paragraphs.

The instruments used by the Navy are the direct reading type (indicating or recording) and are described later in this chapter.

Wind Direction

Wind direction is observed for a 1-minute interval with reference to true north and in 10°-increments in a clockwise direction from true north. When the air is not in motion, the wind is said to be CALM. When instruments for measuring the wind direction are not available or are inoperative, estimate the direction by observing a wind cone or tee, movement of trees, smoke, or by facing into the wind in an unsheltered area.

Do not use the movement of clouds, regardless of how low the clouds are, in estimating the surface wind direction.

Wind Speed

Determine speed of the surface wind to the nearest knot. In general, observed wind speeds are a 1-MINUTE AVERAGE. So far as possible, the average wind speed observation should not be made during a peak or lull in gusty winds or squalls.

Where wind speed instruments are temporarily unrepresentative or not available, estimated speed (including gustiness and squall data) may be determined by use of Appendix VI.

Character and Shifts

The character and shifts of the wind are determined by examining the wind speed indicator/recorder to determine if the required criteria have been met to report the phenomena.

FORMS

Several types of forms are used to record wind data. Some were previously mentioned, such as the MF1-10 shore form, and the NWSC 3140/8 ship form, also recording rolls for the UMQ-5( ) and GMQ-29( ).

MF1-10 Entries

Although the following descriptions of wind element entries are correct, they are brief and the Aerographer should refer to the Federal Meteorological Handbook No. 1 for a more complete and detailed description of the proper procedures.

WIND DIRECTION (COL. 9).—Enter the wind direction to the nearest tens of degrees. Use 2 digits as shown in table 3-1. Enter "00" when the wind is calm. Whenever either the reported wind direction, speed, speed of gusts or squalls is estimated, prefix the direction with an "E".

WIND SPEED (COL. 10).—Enter the wind speed in knots. For calm wind enter "00". When the speed exceeds 99 knots, enter only the tens and units figures and add 50 to the wind direction in column 9; e.g., 112 knots from 270° - - - 7712.

WIND CHARACTER (COL. 11).—Enter gusts by using the symbol "G" followed immediately by the peak speed of gusts observed during the past 10 minutes. Report squalls by the symbol "Q" followed immediately by the peak squall wind observed during the past 10 minutes.

These are reported when they occur regardless of the type of wind equipment utilized.

WIND SHIFTS AND VARIABLE WIND DATA (COL. 13).—A wind shift is always reported when it occurs. To report a wind shift, enter in column 13 the contraction "WSHFT" followed by the time the wind shift began in minutes past the hour using two digits (e.g., WSHFT 37). When the shift is reasonably certain to be associated with a frontal passage, include the contraction "FROPA" immediately after the time (e.g., WSHFT 37 FROPA). If the remark containing this data is not transmitted via longline teletype, the data will then be included

Table 3-1.–Wind direction in tens of degrees

Degrees	Compass Points	Tens of degrees
355-004	N	36
005-014		01
015-024	NNE	02
025-034		03
035-044		04
045-054	NE	05
055-064		06
065-074	ENE	07
075-084		08
085-094	E	09
095-104		10
105-114	ESE	11
115-124		12
125-134		13
135-144	SE	14
145-154		15
155-164	SSE	16
165-174		17
175-184	S	18
185-194		19
195-204	SSW	20
205-214		21
215-224		22
225-234	SW	23
235-244		24
245-254	WSW	25
255-264		26
265-274	W	27
275-284		28
285-294	WNW	29
295-304		30
305-314		31
315-324	NW	32
325-334		33
335-344	NNW	34
345-354		35

in the REMARKS section of the next transmitted report to be sent via longline teletype.

When wind meets the criteria for variable wind, the contraction "WND" will be entered in column 13 followed by the extremes of variability and separated by the letter "V" (e.g., WND 32V05).

WIND SUMMARY DATA (COLS 71, 72 & 73).—A column 71 entry is only made at stations having a continuous instantaneous wind-speed recorder. Enter in knots the highest instantaneous peak gust recorded during the 24 hours ending at midnight. Column 72 is for entry of the peak gust's direction to the nearest 10 degrees. If the direction portion of the record is missing or inoperative, estimate from the column 9 entries and enter to the 8 point compass. Column 73 is for the time of occurrence of the maximum gust and is entered to the nearest minute LST.

NWSC 3140/8 Entries

WIND (COLS. 12, 13, & 14).—Enter the TRUE wind direction, wind speed (in knots), wind shifts, gustiness, and squalls in accordance with instructions for columns 9, 10, and 11 of MF1-10. The difference between land station wind observations and shipboard wind observations is that compensation must be made for the ship's heading and speed, and true wind direction and speed have to be computed; they cannot be observed directly.

Several methods for computing the true wind at sea are available. Two of these methods, the True Wind Computer CP-264/U and the True Wind Observing Method, will be discussed in detail later in the chapter.

When wind indicating or recording equipments is inoperative or unavailable, estimate wind speeds in accordance with criteria listed in Appendix VI. This appendix may also be used to check computed wind speeds. Wind directions may be estimated by observing the direction of travel of sea waves. Remember that such directions are relative to the ship's heading, and they must be converted to true directions.

SUMMARY OF THE DAY (COLS. 52 through 56).—Enter the maximum wind data for the period from midnight to midnight GMT. Enter estimated wind data if recording equipment is not available.

In column 52, enter times to the nearest minute GMT. In columns 53 and 54, enter the positions to the nearest whole degree latitude and longitude. In columns 55 and 56, wind direction and speed is entered as it was entered in columns 12 and 13 of NWSC 3140/8. Directly beneath these column entries, space is provided for entries of gale conditions or greater (34 kns or higher) if the ship is steaming north of 30°N. or south of 30°S. If the ship is steaming between 30°N. and 30°S., make entries in these columns if the wind is 22 knots or greater.

Wind Recorder Charts

Wind recorder charts from the RD-108/UMQ-5 and GMQ-29 recorders are handled in the following manner:

1. At the beginning and end of each chart roll, enter station name (NAS, etc.), date and time that record began/ended, and chart feed rate if different from normal, or if times are not printed on the chart.

2. Change charts at 0000 LST on the first day of each month and at intermediate times as necessary to prevent loss of record.

3. Replace charts in original shipping carton if available, and enter the station name and period of record on the end of the carton. Forward completed charts monthly in accordance with instructions in chapter 11 of this training manual.

4. Power and equipment failure is indicated on the recorder chart by entering the term "POWER FAILURE" or "EQUIPMENT FAILURE" at the point of failure, along with the time (LST) of the failure. When returned to service, the chart should be adjusted to the correct time and a time check entered.

WIND MEASURING SET
AN/PMQ-3( )

OPERATION

Wind Measuring Set AN/PMQ-3, -3A, -3B, and -3C is a portable hand anemometer. It is a combination wind direction and speed indicating unit which indicates direction to 360° and speed from 0 to 60 knots. The wind, upon striking the small cylindrical turbine (fig. 3-1) in the transmitter causes the turbine to rotate. The turbine is linked to a small electrical generator which produces a voltage proportional to the speed of the turbine. The voltage is transmitted to the indicator, which is a voltmeter graduated in knots. The indicator has 2 scales, graduated from 0 to 15 knots and from 0 to 60 knots. The upper trigger on the handle controls the scale to be used.

The direction unit is a twin-tailed assembly with a pointer (vane nose), which faces into the wind, when the brake is released by depressing the vane locking trigger. The index pointer on the vane is then aligned on the direction dial with the direction from which the wind is blowing. To make an accurate direction reading, follow this procedure:

a. Choose a location where there will be, as nearly, as possible, unobstructed wind flow from all directions.

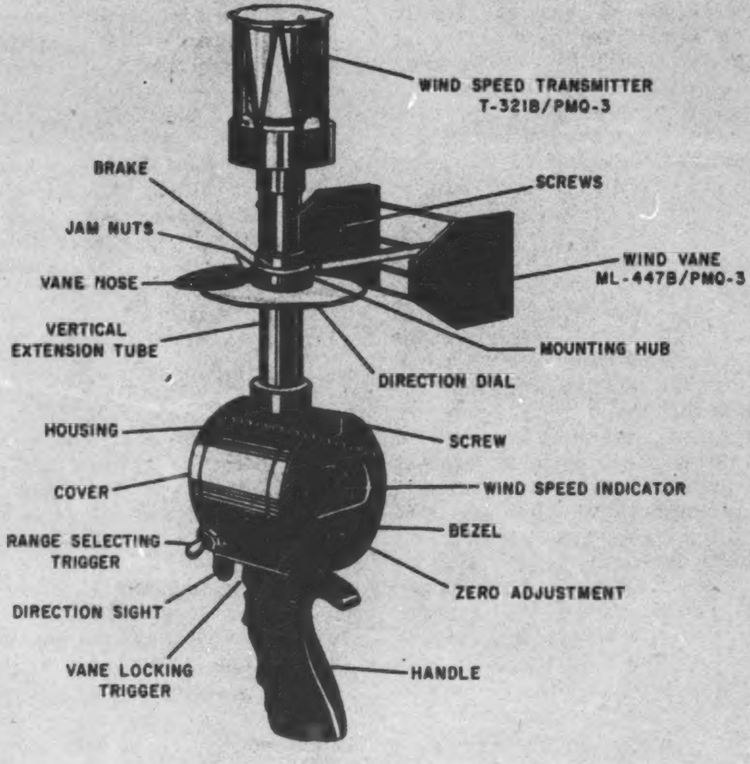

WIND SPEED TRANSMITTER
T-321B/PMQ-3
BRAKE
SCREWS
JAM NUTS
WIND VANE
ML-447B/PMQ-3
VANE NOSE
VERTICAL
EXTENSION TUBE
MOUNTING HUB
DIRECTION DIAL
HOUSING
SCREW
COVER
WIND SPEED INDICATOR
BEZEL
RANGE SELECTING
TRIGGER
ZERO ADJUSTMENT
DIRECTION SIGHT
VANE LOCKING
TRIGGER
HANDLE

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Figure 3-1.—Wind Measuring Set AN/PMQ-3( ).

b. Grasp the instrument by the handle and hold it in an approximately vertical position at arm's length with the sight at eye level.

c. Aim the instrument at a fixed orientation point by aligning the center of the slot in the front of the sight with the center of the strip between the two slots on the rear sight and the fixed orientation point.

d. Press and hold the vane locking trigger. Note the reading on the 0-60 (upper) scale on the wind speed indicator.

e. If the wind speed reading is less than 15 knots as indicated on the 0-60 scale, press the range selecting trigger on the side of the housing (3B and 3C models) or handle (3 and 3A models) and observe the indication on the 0-15 scale.

CAUTION: The range selecting trigger should not be pressed if the initial observation of the wind speed indicator indicates a wind speed in excess of 15 knots as mechanical damage may result due to the slamming of the pointer.

f. The instant the wind speed indication is noted, release the vane locking trigger and carefully lower and tilt the instrument to observe the wind direction reading on the direction dial.

CAUTION: After the vane locking trigger is released, care must be taken not to disturb the vane's position until the direction reading is made.

g. Observe the wind direction reading in whole degrees and then record both the wind direction and speed readings.

The equipment is issued ready for use and comes stowed in a carrying case containing a spare wind speed transmitter and a spare wind vane. The instrument should always be replaced in this carrying case after use. Special care should be taken in removing the anemometer from the case and replacing it in the case because damage may easily result to the wind vane section.

MAINTENANCE

In the care and maintenance of Wind Measuring Set AN/PMQ-3( ), no special service tools are needed. In inspecting the equipment, make certain that the turbine and vane are free to rotate and that there is pointer movement when the turbine is rotated. Check for freeness by holding the instrument in its operating position and walking at a moderate rate of speed in an area where there is no air movement. If the vane assumes the correct position and there is a speed indication on both scales, it is probable that the instrument is in a satisfactory condition.

If trouble develops in the system, refer to table 3-2. This table lists troubles, along with possible causes, and their remedies. Procedures to replace or repair a component when found to be malfunctioning are as follows:

1. Wind speed transmitter.—To replace the wind speed transmitter (fig. 3-1), grasp the transmitter by its cover (never the cage) and give it a slight twist in a counterclockwise direction (looking down on the instrument) and pull it straight off. Remove the spare transmitter from the case in a like manner. Install the spare transmitter by reversing the above procedure, making sure that the unit is securely locked in position.

2. Wind speed indicator.—See technical manual (NA50-PMQ3C-1) for details of procedure. If physical damage is not visible, and as a defective indication may be caused by another component, do not discard the unit until its condition has been proved unsatisfactory by a requisitioned replacement.

3. Trigger and switch assembly.—See technical manual (NA50-PMQ3C-1) for details of procedure. If physical damage is not visible, and as a defective indication may be caused

Table 3-2.–Troubles and remedies (wind speed system–AN/PMQ-3( ))

Trouble	Probable cause	Remedy
No pointer movement 0-60 range or 0-15 range.	Defective detector . . . . . . Defective speed indicator. . .	Replace detector. Replace indicator.
No pointer movement 0-60 range only.	Defective speed indicator. . .	Replace indicator.
No pointer movement 0-15 range only.	Defective switch or defective speed indicator.	Connect the terminals of the switch together; if indication is obtained, replace trigger assembly. If no indication is obtained, replace indicator.
Pointer does not rest on zero when turbine is stationary.	Speed indicator not properly zeroed.	Turn zero set adjustment located on the front of the indicator.
Sluggish pointer movement.	Dirty or damaged speed indicator.	Replace indicator.

by another component, do not discard this unit either until its condition has been proved unsatisfactory by a requisitioned replacement.

4. Wind vane.—Minor defects and dents are not cause for replacement. If twisted parts affect the accuracy, try to straighten them. If the vane is not repairable, the spare wind vane from the case should be installed (See technical manual (NA50-PMQ3C-1) for detailed procedure.) and another wind vane requisitioned from stock spares.

No lubrication or cleaning is required by the operator, except that the wind speed transmitter should be lubricated every 6 months or at any time the turbine appears to be running sluggishly.

Check with your supervisor as to how to lubricate the transmitter; or in the absence of a supervisor, consult the handbook for the instrument.

WIND MEASURING SET AN/UMQ-5( )

Wind Measuring Set AN/UMQ-5( ) (fig. 3-2) is the standard equipment designed to provide a visual indication and/or printed record of wind direction and speed values. Various options of the system are provided to permit continuous recording of wind direction and speed values at several measuring sites.

COMPONENTS

A set includes a minimum of one transmitter, one support, and one recorder or indicator. A maximum of six recorders and/or indicators can be used with each transmitter.

Mounting Options

Although the complete wind measuring set is illustrated in figure 3-2, various options in mounting the display components of the set are shown in figure 3-3.

Transmitter ML-400( )/UMQ-5

The transmitter (fig. 3-2(A)) is a vane mounted on a vertical support. The tail of the vane brings the nose into the wind. The nose consists primarily of a screw-type impeller directly coupled to a tachometer-magneto. The magneto voltage output is directly proportional to the wind speed and is connected to the plug in the transmitter's vertical support through brushes and sliprings, then down to the indicator or recorder whose voltmeter automatically indicates or records the voltage in knots. Motion of the vane is transmitted mechanically to a synchro located inside the enlarged section of the vertical support.

The transmitter is placed on top of a connector housing. The electrical cable, leading from the housing through the support, goes to any one or all of any combination of six repeaters, whether all indicators or all recorders, or a combination of them. A follower synchro then converts the electrical energy into wind direction indication or recording. The transmitter is designed to carry six repeaters.

Support MT-535/UMQ-5

The support (fig. 3-2(B)) is of the tripod-type design, having a tubular upright mast and three legs constructed of tubular steel tubing. Each leg is equipped with a mounting foot. The top of the support is provided with a clamp to hold the transmitter securely in place when mounted. Wires may be run through the center of the mast into the transmitter connector housing. The support may be tilted for servicing the transmitter. A guy plate is provided for the attachment of guy wires, if necessary.

Another support may also be used with this system. It is very similar to the support shown in figure 3-2(B) with only minor changes in fittings and provisions for conduit built into it.

Indicator ID-300( )/UMQ-5

The ID-300( ) indicator (fig. 3-2(C)) consists of two units: the panel assembly and the mounting case which holds the panel assembly. The panel assembly contains the wind direction indicator and the wind speed indicator positioned in two 4-inch dials, the lighting circuits, and the double-range switch for the speed section. The wind direction indicator consists of a synchro follower on whose rotor shaft is mounted a pointer that indicates wind direction values on a 360°-circular scale. The dial is graduated at the cardinal and intercardinal compass points as well as every 5° from north.

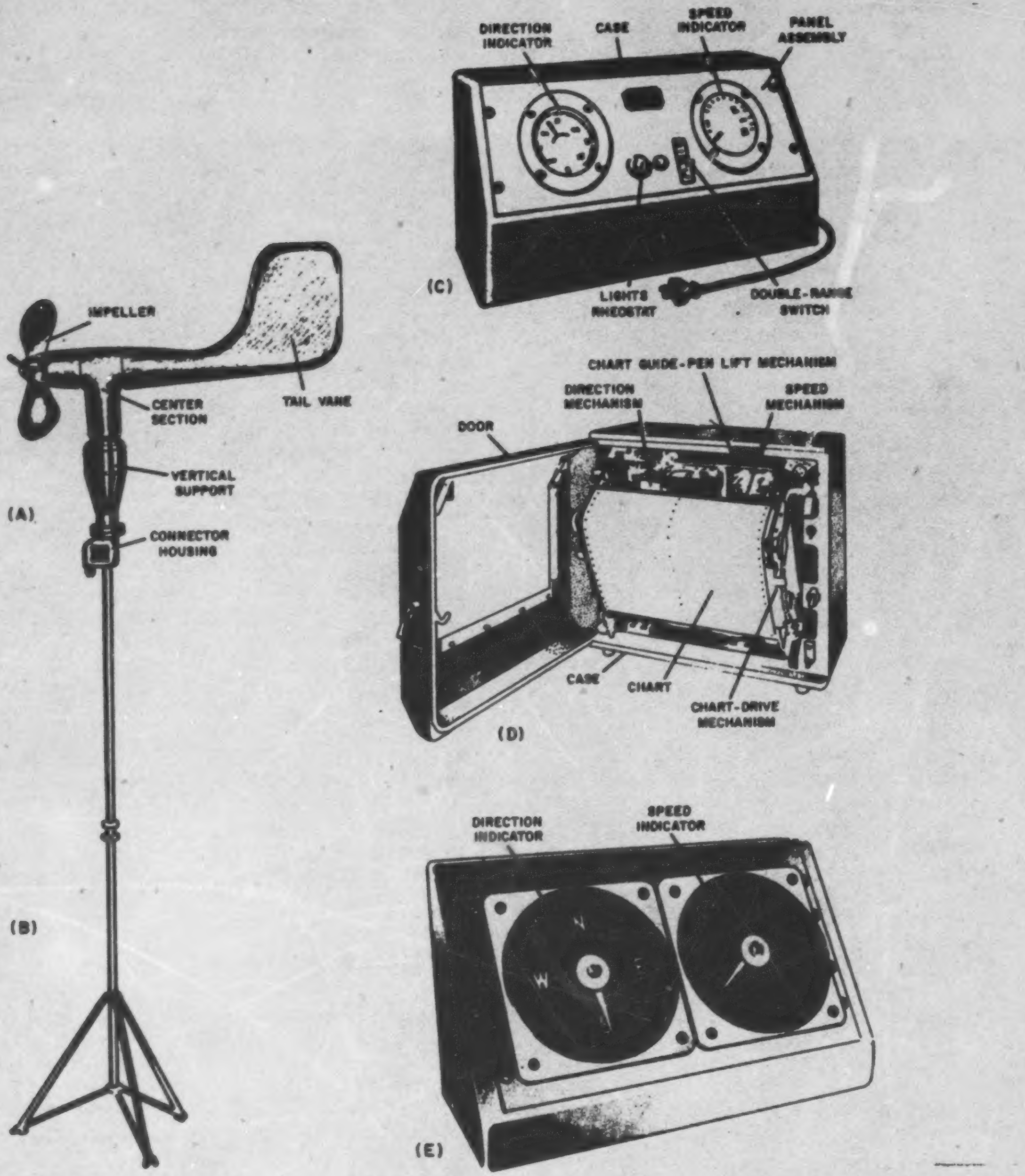
DIRECTION INDICATOR
CASE
SPEED INDICATOR
PANEL ASSEMBLY
(C)
LIGHTS RHEOSTAT
DOUBLE-RANGE SWITCH
IMPELLER
TAIL VANE
CENTER SECTION
VERTICAL SUPPORT
(A)
CONNECTOR HOUSING
CHART GUIDE-PEN LIFT MECHANISM
DIRECTION MECHANISM
SPEED MECHANISM
DOOR
CASE
CHART
CHART-DRIVE MECHANISM
(D)
(B)
DIRECTION INDICATOR
SPEED INDICATOR
N
W
E
(E)

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Figure 3-2.—Wind Measuring Set AN/UMQ-5( ). (A) Transmitter ML-400( )/UMQ-5; (B) Support MT-535/UMQ-5; (C) Indicator ID-300( )/UMQ-5; (D) Recorder RD-108( )/UMQ-5; (E) Indicator ID586( )/UMQ-5.

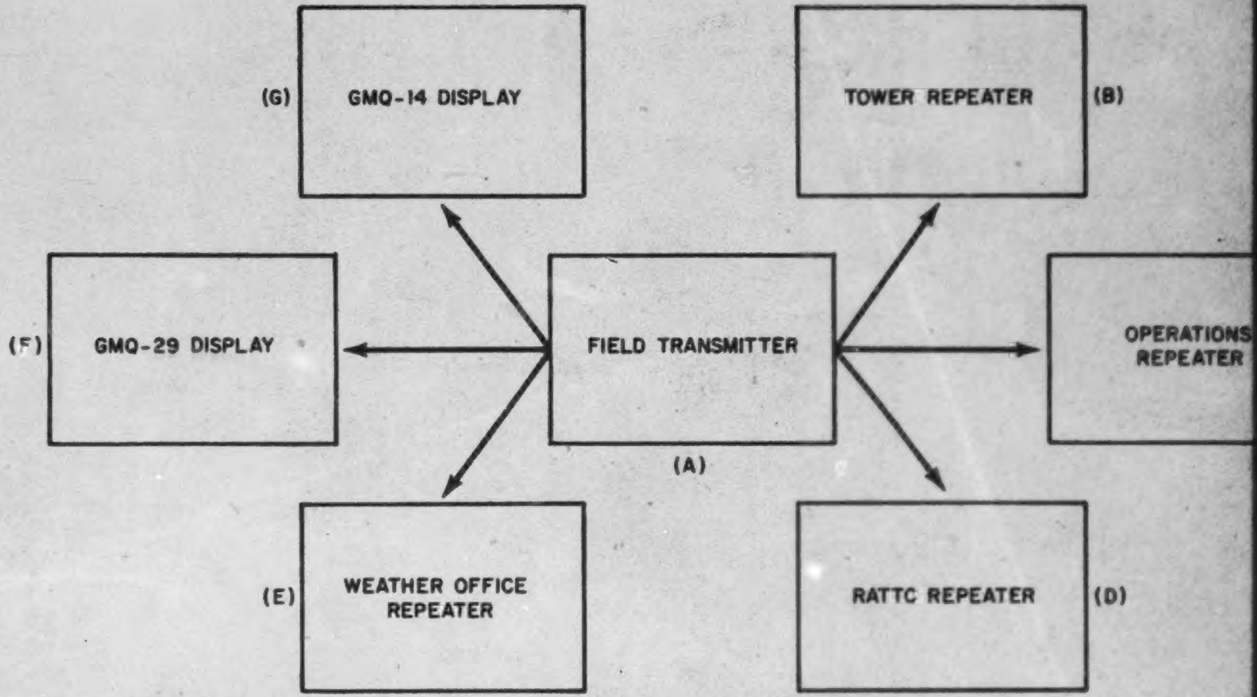
(G)
GMQ-14 DISPLAY
TOWER REPEATER
(B)
(F)
GMQ-29 DISPLAY
FIELD TRANSMITTER
(A)
OPERATIONS REPEATER
(E)
WEATHER OFFICE REPEATER
RATTC REPEATER
(D)

Figure 3-3.—Display components mounting options.

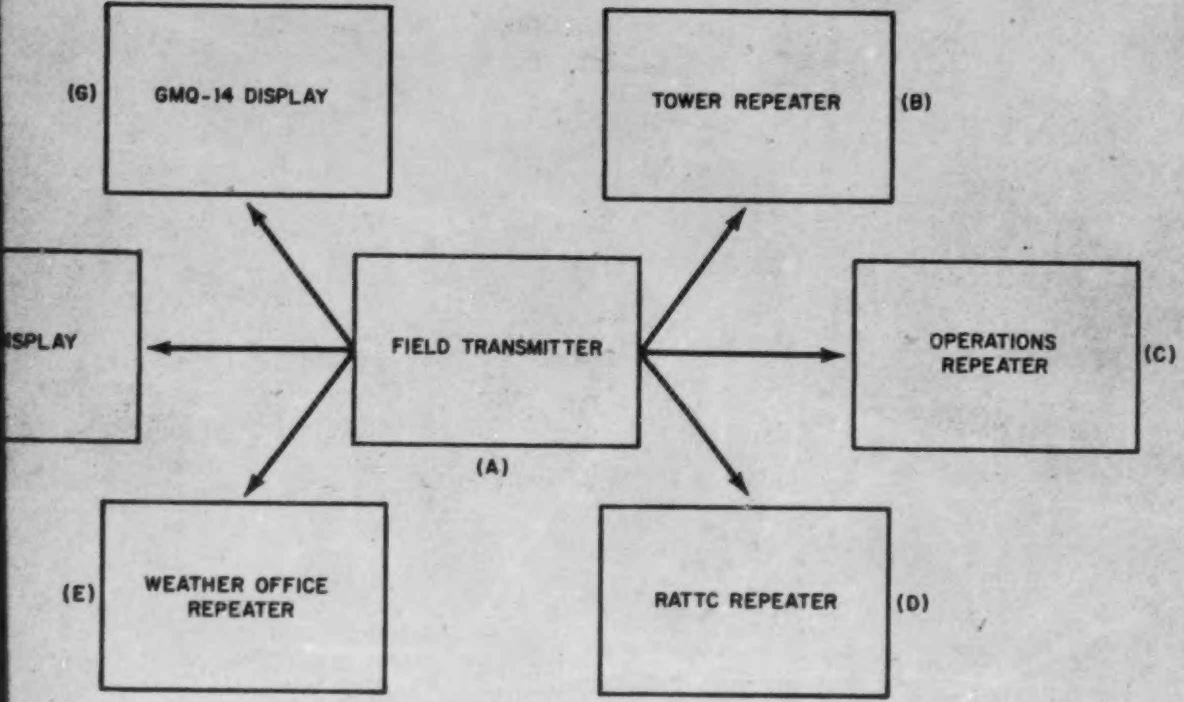
(G)
GMQ-14 DISPLAY
TOWER REPEATER
(B)
ISPLAY
FIELD TRANSMITTER
(A)
OPERATIONS REPEATER
(C)
(E)
WEATHER OFFICE REPEATER
RATTC REPEATER
(D)

Figure 3-3.—Display components mounting options.

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The wind speed indicator is a precision, high-shock type voltmeter whose pointer indicates wind speed in knots on a scale whose ranges are 0 to 60 knots or 0 to 120 knots. The scales are circular about an arc of approximately 270°. Selection of ranges is accomplished by the use of the double-range switch to change range from 0 to 60 knots to 0 to 120 knots.

Indicator ID-586/UMQ-5

The ID-586 indicator (fig. 3-2(E)) consists of a speed indicator (voltmeter) and a direction indicator (synchro) mounted on a panel which is inserted in a case. A six-tapped dummy load register is attached to the terminal board mounted in the bottom of the case. No panel lighting or dual-range circuits are installed in this indicator. Each of the indicating assemblies (speed and direction) is removable and may be installed individually.

Indicators GMQ-29/UMQ-5

The UMQ-5( ) is also used to feed data on wind direction and wind speed into the new digital readouts of the AN/GMQ-29( ), Automatic Weather Station. This data is constantly displayed on the readout panel through a very complex system of electronic data reception and computations. This computer system is too detailed and complex for discussion in this manual. For further information on its theory of operation and application refer to NAVAIR 50-30GMQ-29-1.

Recorder RD-108( )/UMQ-5

The RD-108( ) recorder (fig. 3-2(D)) basically consists of a direction mechanism, speed mechanism, chart drive mechanism, chart guide-pen lift mechanisms, chart, and case. A description of each is given in the following paragraphs.

WIND DIRECTION MECHANISM.—The wind direction mechanism consists of a synchro follower which positions the pen through a gear train which converts 540 wind degrees of synchro rotation to approximately 62° of pen rotation, corresponding to 540 wind degrees of the chart. Whenever wind conditions are such that the pen would run off the chart in recording wind direction, a repositioning mechanism is energized. This mechanism removes power from the synchro, drives the pen to the approximate center of the chart, and then returns power to the synchro so that recording is continued after the pen is displaced 360 wind degrees toward the middle of the chart.

The direction inking system consists of the pen and a stationary ink tank. The pen is designed to fit into a pen holder attached to the synchro gear train and has a small tube which fits into the ink tank and feeds ink by capillary action to the penpoint which rests on the chart.

WIND SPEED MECHANISM.—The wind speed mechanism consists of a voltmeter mechanism which drives the wind speed pen across the speed section of the chart. Also included in the speed section is a six-tapped dummy load resistor connected across a terminal board. The pen and inking system of the speed section is identical to that of the direction section.

CHART DRIVE MECHANISM.—The chart drive mechanism is a removable, self-contained assembly, consisting of a frame and various mounted parts. The assembly contains the chart drive motor, drive gear train, drive roll, idler roll, chart trough, removable takeup reel, takeup motor, and hinged panel. Also mounted on the assembly are the speed change gears, chart drive ON-OFF switch, takeup motor microswitch, and the plug through which power is introduced to the mechanism. When the mechanism is seated inside the recorder case and the chart drive switch is in the ON position, the chart drive motor moves the chart across the drive roll and under the pens at a rate determined by the change gears selected. The chart is rerolled on the takeup reel by the takeup motor.

CHART GUIDE-PEN LIFT MECHANISM.—The chart guide-pen lift mechanism is an assembly which guides the chart across the drive roll, holds the chart drive mechanism in place, and provides a mounting for the illuminating lamps and the direction and speed scales. The assembly is pivoted so that it may be lifted to gain access to the chart drive mechanism and ink tanks, and to lift the pens off the chart.

CHART.—The strip-type chart is divided into two main channels. The right channel is for the recording of wind speed and is graduated every

2 knots from 0 to 120 knots. The left channel is for the recording of wind direction and is graduated every 10° over a 540° range.

Direction letters representing the cardinal compass joints (N-E-S-W-N-E-S) are printed above the appropriate numerical direction values. The chart is designed for use with the 3-inches-per-hour chart speed, and the time lines are graduated to 10 minutes and numbered every hour. Holes on either side and in the center of the chart provide positive drive between the chart and the sprocket drive roll. The chart has a running time of approximately 15 days.

CASE.—The case is made of cast aluminum and has a hinged door. The door contains a plastic window large enough for viewing the indication scales, pens, and 7 inches of the past record. It also is provided with a rubber gasket to ensure a tight fit when the door is closed. A recess at the bottom rear of the case has connections for the power and intercomponent cables.

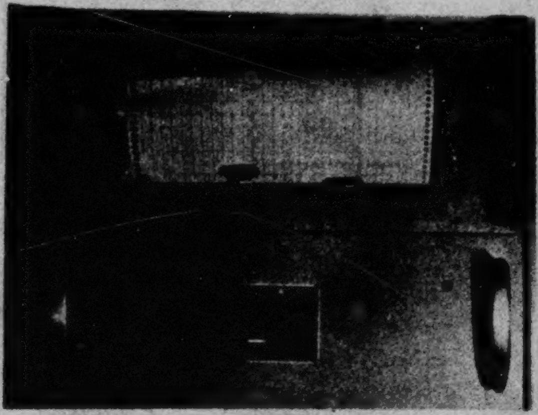
Recorder RO-447/GMQ-29

This is an analog recorder (fig. 3-4) newly designed for use with the AN/GMQ-29( ), Automatic Weather Station, utilizing inputs from the UMQ-5( ) Wind System, through a complex system of electronic data reception and computations prior to being recorded. The recorder records wind direction, wind speed, and rainfall (discussed in chapter 4). It differs in its presentation of recorded data from the RD-108/UMQ-5 in that it records straight lines instead of curved lines, uses a different chart, and has different chart speeds. Presently it uses ink pens and tanks similar to the RD-108/UMQ-5, but plans are for a changeover to a ballpoint-type pen in the near future. Maintenance of this recorder is covered in chapter 4 under the AN/GMQ-29( ) Automatic Weather Station.

Model Differences/UMQ-5

Transmitters ML-400B and ML-400C are identical to earlier models, except that they are larger in the synchro section to allow for the use of six repeaters.

The ID-586 indicator has no predecessor. The ID-300B and ID-300C indicators are identical with older models with the exception of the resistance strip to allow for the adjustments needed when from one to six repeaters are used.



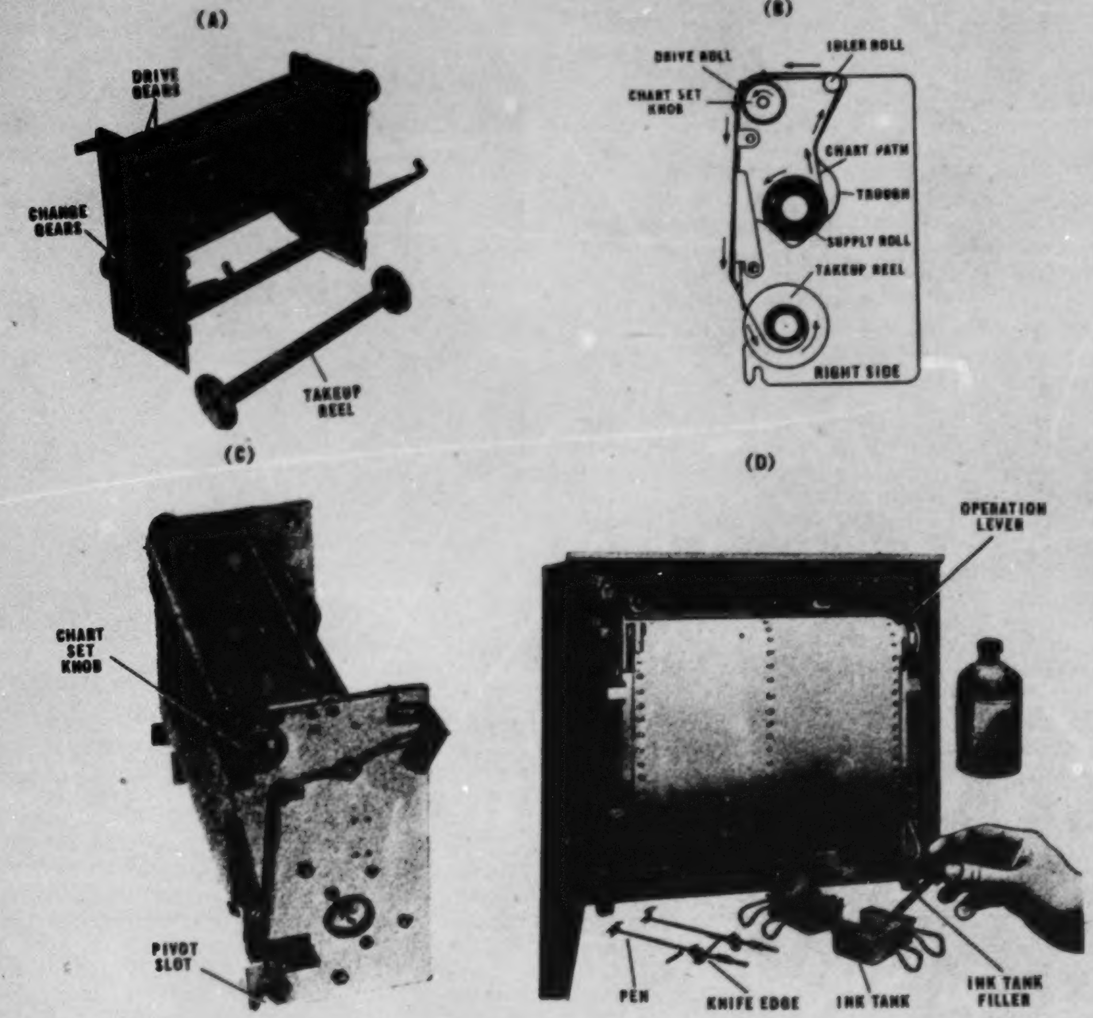
209.361
Figure 3-4.—Analog Recorder RO-447/GMQ-29.

The RD-108B and RD-108C recorders differ from earlier models primarily in the relay system to allow for the one to six repeaters running from the same transmitter. The recorder that is available with the AN/UMQ-5D has a pen stop arrangement that prevents the pen from catching in the center holes of the chart.

OPERATION

Installation of Chart Speed Change Gears

The recorder is equipped with chart drive gears to give a chart speed of 3 inches per hour, which matches the time graduations of the chart supplied. (See fig. 3-5(A).) Change gears to provide a chart speed of 6 inches per hour or 1 1/2 inches per hour are mounted on a stud on the left side plate of the chart drive mechanism. The change gear arrangements


(A)
DRIVE GEARS
CHANGE GEARS
TAKEUP REEL
(B)
DRIVE ROLL
IDLER ROLL
CHART SET KNOB
CHART PATH
TROUGH
SUPPLY ROLL
TAKEUP REEL
RIGHT SIDE
(C)
CHART SET KNOB
PIVOT SLOT
(D)
OPERATION LEVER
PEN
KNIFE EDGE
INK TANK
INK TANK FILLER

209.121

Figure 3-5.—Recorder RD-108( ) views. (A) Recorder chart drive mechanism (left side view); (B) chart threading diagram; (C) recorder chart drive mechanism (right side view); (D) filling ink tanks.

given in the equipment handbook show the combination of gears to obtain the different rates of chart speed. To change the rate of chart speed, consult the equipment handbook.

Installation of Chart

Install the chart according to figure 3-5(B). Cut the chart corners as shown in figure 3-5(A). Wind several turns of the tapered end around the takeup reel before installing the reel in the chart drive mechanism.

Installation of Chart Drive Mechanism

Lift up the operation levers (fig. 3-5(D)). Place the chart drive mechanism in the recorder so that the pivot slots (fig. 3-4(C)) in the mechanism side plates are seated on the pivots mounted in the case. Return the mechanism to its normal operating position. Lower the operation levers over the chart drive roll.

Installation of Ink Tanks and Pens

Fill both ink tanks about three-fourths full through the pen opening; use the ink and ink tank filler furnished with the recorder as shown in figure 3-5(D). Do not use standard writing inks. Keep the bottle tightly capped to prevent dirt from getting into the ink.

Raise the scale plates and insert the ink tanks in the receptacles on top of the speed and direction mechanism assemblies and see that they are under the spring clips.

Set the pen elements in the pen element forks (penholder) by seating the knife edges of the elements into the slots of the fork.

NOTE: The ink tanks and pens may be installed or removed for servicing when the chart drive mechanism is removed, tilted forward, or is in its operating position.

Zeroing Speed Pen

With the chart drive mechanism installed and a chart installed in the drive mechanism, loosen the thumbscrew securing the speed pen zero adjustment lever and adjust the speed pen to read zero on the chart (not the scale). Disconnect the leads from the synchro follower for this adjustment.

Filling Pens

Fill the ink tank with the ink tank filler furnished with the recorder. Compress the bulb of the ink tank filler and lay the flat side of the soft rubber tip on the chart. Insert the penpoint into the hole in the rubber tip and let the filler suck in ink from the ink tank through the pen. The pen feeds from the ink tank by capillary action once it is filled.

Remove the pen element from the filler. The pen should rest lightly on the chart.

Swing the pen across the chart a few times. If it does not write properly, the pen probably has an air bubble in it, in which case the pen filling operation must be repeated.

NOTE: Do not apply power to the recorder when the direction pen is being swung.

Be sure that the pen is properly seated and that it does not rub on the ink tank. Also, check to see that it does not rub on the indication scales and the pen lift bar when they are in their operating positions. The indicating flag above the pen must not touch the scale plate.

NOTE: The pen element is correctly balanced at the factory when full of ink and will stay off the chart until the pen is filled.

Setting Chart to Time

With the power cable connected and all power switches in the ON position, turn the chart set knob until the correct time line on the chart is under the pens. (See fig. 3-5(C).)

NOTE: After time setting the chart, do not tilt the chart drive mechanism forward; power supplied to the chart drive motors will be interrupted, thus losing the time setting.

Unrolling Chart for Examination

The chart record may be unrolled from the takeup reel while the chart mechanism is operating by grasping the chart on either side, near the takeup reel, and pulling the chart from the reel. Be careful to keep the chart straight and taut as it is allowed to rewind on the reel.

Removing Chart From Takeup Reel

Remove the chart from the takeup reel by first removing the reel from the recorder. Then pull the plain flanged end from the core of the reel. Slide the chart off the core.

Transmitter and Indicators

The transmitter requires no operating procedures. The only operation necessary for Indicator ID-300 is the adjustment of the light rheostat and switching the range selector switch as desired. Indicator ID-586 requires no operating procedures.

MAINTENANCE

This equipment generally requires very little maintenance. The maintenance of this equipment consists mostly of inspection and lubrication.

Transmitter Maintenance

Once a week (or more often during severe weather conditions) visually inspect the transmitter for evidence of physical damage, such as broken impeller, rust, or weakened mast. Under normal conditions the equipment should require lubrication every 2 years. However, in a subtropic or polar climate the equipment may need lubrication more often.

Normally, an AG1 or AGC accomplishes the lubrication and other maintenance which requires the dismantling of the set. If the AG3 or AG2 is on a one-man billet, or there is no AG1 or AGC, request assistance from a nearby weather unit.

Indicator Maintenance

The only service inspection required for the indicators, at the Aerographer's Mate 3 and 2 levels, is an observation of their operation to detect erroneous readings or failure of the lamps.

Recorder Maintenance

It is not recommended that any parts be repaired or replaced in the recorder other than lamp bulbs, pens, ink tanks, chart drive motors, and chart drive switches. Replacement of other recorder parts requires the use of overhaul facilities.

When cleaning the recorder, DO NOT clean electrical parts. Clean the mechanical parts as follows:

Wash exterior painted surfaces and the window with soap and water; rinse and dry thoroughly. Do not wash the inside of the case. Do not clean the windows with a solvent since minute cracks may result.

Clean the ink tanks by prying off the covers, removing them from the recorder, and washing the parts in warm water. Rinse and dry thoroughly. If washing does not remove all of the dried ink, loosen the remainder by soaking the tank in alcohol; then wash as before. Be sure the vent holes in the cover are open and that the cover is not bent in removing.

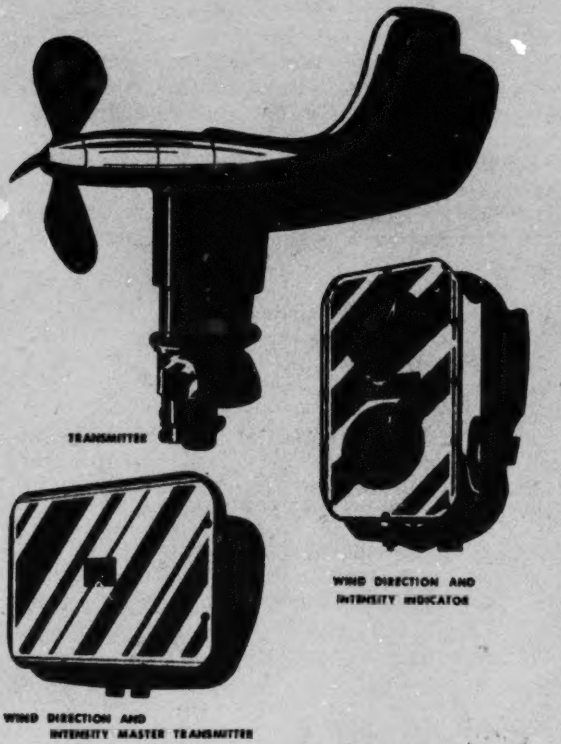
Clean the pen element by blowing water or alcohol through it with the pen filler. Loosen clogged ink particles that block the pen by running a fine piano wire through the tube and then cleaning as above.

The recorder should be lubricated every quarter. This interval is established for operation on a 24-hour basis under moderate climatic conditions. Whenever climatic conditions necessitate more frequent intervals for general servicing, the lubrication interval should be shortened accordingly. Avoid overlubrication; overlubrication is injurious to the recorder. Inspect the equipment after lubrication. Remove all excess oil, as it tends to collect dust or gum up. Oil may be properly applied by dipping a toothpick in the oil and applying it to the surface to be lubricated. Remove excess oil with a clean, lint-free cloth.

The pen elements are properly balanced when they are full of ink, and the balance adjustment should not be changed unless necessary. Whenever rebalancing is required, screw the two balance weights as necessary along the shaft on the rear of the pen to rebalance. The pen balance should be such that when the chart is tapped lightly with one finger, the pen bounces up and down on the chart. A pen pressure that is too heavy on the chart causes the pen to drag toward the center of the chart or noticeably reduces the speed of response of the pen. Accordingly, if maximum response speed is desired, the pen pressure must be no greater than is necessary for satisfactory inking. Handle the pen element carefully; a bent element causes incorrect readings.

SHIPBOARD WIND SYSTEM TYPE B3

Type B3 Wind Indicating Equipment (fig. 3-6) is installed aboard some ships to determine wind speed and direction. Aboard aircraft carriers this system is supplemented with a wind recorder of the type used with the shore system (fig. 3-5). It, however, only records the apparent wind direction and speed, which must then be used to compute true wind direction


TRANSMITTER
WIND DIRECTION AND INTENSITY INDICATOR
WIND DIRECTION AND INTENSITY MASTER TRANSMITTER

209.118
Figure 3-6.—Type B3 Wind Indicating Equipment (shipboard).

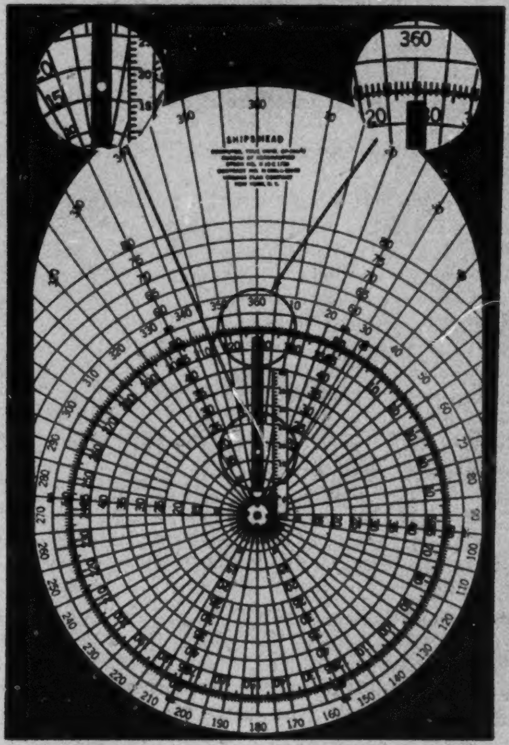
and speed. The several methods used to do this are discussed later in this chapter.

This equipment is under the cognizance of NAVSEA and is serviced by the IC Electricians. The only responsibility the Aerographer has, in connection with this equipment, is reading the indicated data and maintaining the charts and ink wells on the recorder unit (See discussion earlier in chapter on the UMQ-5( ) recorder). If errors appear to exist in the readings obtained from the equipment, notify the IC Electricians.

WIND COMPUTERS

TRUE WIND COMPUTER CP-264/UM

A plastic circular slide rule, True Wind Computer CP-264U, is issued to all ship weather offices for true wind computation (fig. 3-7).



209.362
Figure 3-7.—True Wind Computer CP-264/U.

True Wind Computer CP-264U is an assembly of imprinted plastic plates used aboard ship to compute true wind speed and direction when the apparent wind speed and direction, and ship's course and speed are known. The computer is also used to determine the ship's course and speed required to produce a desired apparent wind direction and speed. The computer consists of an oval base plate and a clear plastic compass rose fastened with a center pivot. The compass rose is free to rotate and to slide along the long axis of the base plate. All computations are made directly on the computer, and solutions are read directly off its scales. Directions for use are printed on the reverse side of the base plate. (The directions on the computer use the term "relative wind", whereas this text and FMH # 1 use the term "apparent wind." Both refer to wind determined from equipment orientated on the bow of the ship.)

An example of how the computer is used for the determination of true wind direction and speed is set out below:

Assume that the apparent wind direction and speed are 300° and 18 knots, and the ship's course and speed are 080° and 16 knots.

1. Slide the rotor disc along the ship's speed reference line until the center index of the rotor disc is opposite the ship's speed, 16 knots, and then rotate the disc until the ship's heading, 080° true on the compass rose of the rotor disc, is directly over the 000°/360° bearing radius of the base plate.

2. Plot with a grease pencil a dot on the rotor disc at the point determined by the apparent wind direction, 300° true, and speed 18 knots, utilizing the base grid.

3. Slide the rotor disc to the zero of the ship's speed reference index (the center of the concentric circles of the base plate) and rotate the disc until the grease pencil dot, previously plotted, lies along the 000°/360° bearing radius of the base plate. The true wind direction, 328°, can now be read directly off the rotor disc over the 000°/360° bearing radius of the base plate. The true wind speed, 17.5 knots, can now be read directly opposite the grease pencil dot by utilizing the ship's speed reference index.

For the determination of a ship's course and speed required to produce the desired apparent wind direction to produce the desired wind direction and speed, assume that the apparent wind direction desired is 5° off the port bow and the apparent wind speed is 40 knots, actual apparent wind direction and speed are 300° and 18 knots, present ship's course is 080° true, and present ship's speed is 16 knots.

1. Repeat steps 1, 2, and 3 of the above example to find the true wind direction and speed of 328° and 17.5 knots.

2. Manipulate the rotor disc (by rotation and sliding along the 000°/360° bearing radius of the base plate) until the grease pencil dot, the head of the true wind vector, is directly over the reference point on the base plate as determined by the given requirements of the desired apparent wind (direction at 5° off the port bow and speed of 40 knots across the deck), utilizing the grid of the base plate.

3. Read directly off the rotor disc the ship's course, 340° true, which is directly over the 000°/360° bearing radius of the base plate. Read directly the ship's speed, 23.5 knots, opposite the center of the rotor disc, from the ship's speed reference index. This ship's course, 340° true, and a speed of 23.5 knots, with the given true wind direction and speed, will produce the desired apparent wind direction, 5° off the port bow, and a speed of 40 knots across the deck.

Checking Computed Winds

The following may be used to check computed wind values:

1. The true direction of the wind is always on the same side of the ship as the apparent direction, but farther from the bow (port or starboard) than the apparent direction.

2. The true speed of the wind is greater than the apparent speed whenever the apparent direction is aft of the beam.

3. The true speed of the wind is less than the apparent speed whenever the true direction is forward of the beam.

TRUE WIND OBSERVING METHOD

In the absence of a computer, the true wind direction may be observed by noting the direction from which small wavelets, ripples, and sea spray are coming. To accomplish this, sight along the wave crests, then turn 90 degrees to face the advancing waves; this is the true direction, which is evaluated to the nearest 10 degrees. (See table 3-1.)

The true wind speed may be estimated by observing the sea condition and referring to table 3-3 or Appendix VI. However, the observer should be aware of the assumptions upon which these estimations are based, such as that the wind is well removed from land and that the wind has been blowing from a constant direction and speed long enough to cause the present sea condition.

Some of the factors which will result in an underestimation of true wind speed are as follows:

1. Off-shore winds within sight of land.

2. Moderate to heavy precipitation causing a smoother than normal sea condition.

Table 3-3.–True Wind Speed From Sea Condition

Knots	Sea Conditions	Probable wave height in feet
0-1	Sea smooth and mirrorlike	
1-3	Scalelike ripples without foam crests	1/4
4-6	Small, short wavelets; crests have a glassy appearance and do not break	1/2
7-10	Large wavelets; some crests begin to break; foam of glassy appearance. Occasional white foam crests	2
11-16	Small waves, becoming longer; fairly frequent white foam crests	4
17-21	Moderate waves, taking a more pronounced long form; many white foam crests; there may be some spray	6
22-27	Large waves begin to form; white foam crests are more extensive everywhere; there may be some spray.	10
28-33	Sea heaps up, and white foam from breaking waves begins to be blown in streaks along the direction of the wind; spindrift begins	14
34-40	Moderately high waves of greater length; edges of crests break into spindrift; foam is blown in well-marked streaks along the direction of the wind	18
41-47	High waves; dense streaks of foam along the direction of the wind; crests of waves begin to topple, tumble, and roll over; spray may reduce visibility	23
48-55	Very high waves with long overhanging crests. The resulting foam in great patches is blown in dense white streaks along the direction of the wind. On the whole, the surface of the sea is white in appearance. The tumbling of the sea becomes heavy and shocklike. Visibility is reduced	29
56-63	Exceptionally high waves that may obscure small and medium-sized ships. The sea is completely covered with long white patches of foam lying along the direction of the wind. Everywhere the edges of the wave crests are blown into froth. Visibility reduced	37
64 and over	The air is filled with foam and spray. Sea completely white with driving spray; visibility very much reduced	45

3. Winds have just sprung up or increased in speed.

Some of the factors contributing to an overestimation of true wind speed are as follows:

1. A decreasing wind speed.

2. Waves running into shallower water.

MAINTENANCE

For maintenance procedures for computers refer to chapter two.

> NOTE: Changes to all column numbers and entries on NWSC Form 3140/8 were received too late for inclusion in this manual. Where errors in column numbers appear, refer to the U.S. Navy Supplement to FMH #1, Chapter 13, Marine Aviation Observations for the most recent amplifying instructions.

CHAPTER 4

TEMPERATURE, HUMIDITY, AND PRECIPITATION

Many parameters are important in the field of meteorology; included among them are temperature, humidity, and precipitation. In this chapter the various terms associated with temperature, humidity, and precipitation will be defined, along with a description and use of the various types of sensing equipment, both manual and electronic, including a brief résumé of the oceanographic sensors.

TEMPERATURE, HUMIDITY, AND PRECIPITATION

Before proceeding with a discussion of temperature, humidity, and precipitation, one needs to have a working knowledge of some of the terms used to define them.

DEFINITIONS

1. Temperature. Temperature is defined as the measure of molecular motion or the degree of heat of a substance. It is measured on an arbitrary scale from absolute zero where the molecules theoretically stop moving. A longer and more comprehensive definition is given in chapter 12 of this training manual, as are descriptions of the temperature scales in use in meteorology today.

Temperature, as used in surface observations, refers primarily to the free air or the ambient temperature close to the surface of the earth. Other temperatures are also observed during the course of an observation, such as the maximum, the minimum, sea water, and others.

2. Humidity. Humidity is the state of the atmosphere with respect to water vapor content. However, since there are several ways in which to express the water vapor content, it is better to specify which type of humidity is meant.

3. Dew point. The dew point is defined as the temperature to which a sample of air must be cooled, while the mixing ratio and barometric pressure remain constant, in order to attain saturation with respect to water.

The dew point can never exceed the dry-bulb temperature in any given observation. When the air is saturated, the dew point and the temperature are the same and the relative humidity is 100 percent.

4. Dry-bulb temperature. The dry-bulb temperature is the natural temperature of the ambient atmosphere at the point and time of observation and is synonymous with the surface temperature.

5. Wet-bulb temperature. The wet-bulb temperature is the lowest temperature to be secured in the ambient atmosphere in its natural state by evaporating water from the wick-covered bulb of a thermometer at a specified rate of ventilation. It differs from the dry-bulb temperature in an amount dependent on the temperature and humidity of the air. This difference is termed the wet-bulb depression.

6. Relative humidity. Relative humidity, with respect to water, is the ratio of the actual vapor pressure in the air to the saturation vapor pressure that would exist if the sample of air were saturated at the same pressure and temperature.

7. Psychrometer. A psychrometer is an instrument used for measuring water vapor content of the atmosphere. It consists of two thermometers, one of which (the dry bulb) is an ordinary glass thermometer, while the other (the wet bulb) has its bulb covered with a jacket of clean muslin which is saturated with distilled water prior to an observation. When the bulbs are suitably ventilated, they indicate the thermodynamic wet- and dry-bulb temperature of the atmosphere.

8. Precipitation. Precipitation is any and all forms of water particles, whether liquid or solid, that fall from the atmosphere and reach the ground. It is distinguished from clouds, fog, dew, etc., in that it must "fall"; and from clouds and virga, in that it must reach the ground. The amount of fall is usually expressed in inches of liquid water depth of the substance that has fallen at a given point over a specified period of time.

9. Precipitation gage. A general term for any device that measures the amount of precipitation.

10. Hygrothermometer. An instrumental system for obtaining dew point and ambient air temperatures from dial indicators or recorder traces and the use of remoted sensors as thermometers. The hygrothermometer, for the Navy, is the temperature/humidity portion of Semiautomatic Meteorological Station AN/GMQ-14. The Automatic Weather Station AN/GMQ-29 is an equivalent system.

11. Station standard system. For the Navy, the station standard system is the AN/GMQ-14 or AN/GMQ-29. (Liquid-in-glass thermometers are the station standard system for those stations not equipped with an AN/GMQ-14 or AN/GMQ-29.)

12. Station standby system. The station standby system, for the Navy, consists of the various liquid-in-glass thermometers or psychrometers.

DETERMINING TEMPERATURE, HUMIDITY, AND PRECIPITATION

Throughout the Naval Weather Service today various assortments of temperature, humidity, and precipitation devices exist; they are completely automatic, semiautomatic, or manually operated.

The order of precedence for use of the various sensing instruments depends on the elements being sensed. For temperature and humidity, the first order of priority is the hygrothermometer or equivalent system which is the Semiautomatic Meteorological Station AN/GMQ-14 ( ), and the temperature/dew point temperature sensing system of the Automatic Weather Station AN/GMQ-29, respectively. If these systems are not available or properly operating, the next choice will be the psychrometers, the hand-held electric psychrometer AN/ML-450A/UM or the manual sling and rotor psychrometers, which utilize the liquid-in-glass type of thermometers.

Remoted Sensor Reading

When the AN/GMQ-29( ) is used to obtain psychrometric values, the dry-bulb and dew-point temperatures are read to the nearest whole degree directly from the digital windows. When the AN/GMQ-14( ) is used, these values are obtained from the left-hand edge of the recorder traces. These values are then used to determine the remaining psychrometric data that is required.

Psychrometers

SLING AND ROTOR PSYCHROMETERS.—Procedures for exposure, moistening the wet-bulb, aspiration, and reading the thermometers are detailed in FMH-1.

ELECTRIC PSYCHROMETER.—Procedures for this instrument vary from those outlined in FMH-1 for psychrometers.

1. Place the instrument on a flat surface with the graduations of the thermometer facing upward and the air intake positioned into the wind and to the left of the operator, or

2. Grasp the instrument in the left hand with the fingers fitting the curved portion of the case, the graduations of the thermometers facing the operator, and the air intake pointing to the left and into the wind.

CAUTION: In either position, the air intake and both exhaust ports must be entirely free of obstructions and far enough away from the operator's body or any other source of moist air or temperature that may cause a false reading.

Turn the switch knob clockwise to start aspiration. If thermometer illumination is desired, continue turning the knob clockwise until sufficient light intensity is obtained.

When the wet-bulb temperature stabilizes at a minimum value, note the readings of both thermometers and turn off the switch by turning the knob counterclockwise.

Expose the psychrometer to the free air for at least 5 minutes before using it for readings.

Exposure of this instrument is dependent on the outside air temperature. If it is 50° F or above, expose the psychrometer to ambient air conditions without the ventilating fan running. When the outside air temperature is below 50° F, expose the psychrometer to ambient air with the ventilating fan running.

Thoroughly saturate the wet-bulb wick, with pure water, taking every precaution to prevent water from contacting either the thermometer tube or the dry bulb. Any moisture which may have contacted the dry bulb must be removed.

After observing the wet- and dry-bulb temperatures, calculate the difference between the dry-bulb and the wet-bulb temperature readings. After the difference or wet-bulb depression is obtained, the next step is to compute the dew point and relative humidity by use of Psychrometric Computer CP-165/UM. The instructions are printed on the computer. The psychrometric computer is used, utilizing the scale closest to the NORMAL station pressure (e.g., sea-level stations will use a 30-inch scale for all observations). If the normal station pressure is not known, refer to FMH No. 1 to determine the appropriate scale to use based on the elevation of the station.

Precipitation

For determining the amount of precipitation, most Naval Weather Service units employ the 4-inch rain gage or the tipping-bucket rain gage ML-558, which is an integral part of the AN/GMQ-29( ) and AN/GMQ-14( ).

Precipitation is measured on the basis of the vertical depth of water, or water equivalent, which would accumulate within a specified time on a level surface.

The inch is the unit of measurement for precipitation. The vertical depth of water, or water equivalent, is expressed to the nearest 0.01 inch; less than 0.005 inch is called a trace.

Precipitation measurements are made from samples caught in gages, or from samples taken from representative areas when the catch of solid forms in the gage is not representative.

Precipitation observations are taken at the time of each regular 6-hour observation and at the time of the midnight observation.

The tube of the 4-inch rain gage, when full, holds 1 inch of rainfall. In the event that more than 1 inch falls between the above-mentioned observations, the excess drains into the overflow container. At the next observation the amount collected in the measuring tube and overflow container is measured.

The rain gage unit of the AN/GMQ-29( ) and AN/GMQ-14( ) records each 0.01 inch of liquid water precipitation that falls at the station.

The depth measurement of the water equivalent of the solid forms of precipitation, such as snow, ice pellets, hail, and freezing rain, is more difficult to obtain. The rain gage can be used, provided the collector ring and measuring tube are removed. The solid forms are collected in the overflow container. At the time of the observation a measured amount of warm water can be added to the contents of the container to melt the solid forms. Once melted, the measurement can be made as for rainfall. The added amount of water, of course, must be deducted in computing the total water equivalent. In measuring snow, another method is to obtain a definite volume of the snow from a representative area by removing the overflow container and using it like a doughnut cutter to remove a snow section. This can be melted and measured as described above.

When the water equivalent of snow cannot be accurately measured by melting, the observer may use one-tenth of the average snow depth as the water equivalent; that is, 10 inches of snow correspond to 1 inch of melted snow.

However, when use of a ratio method is necessary and the mean ratio for the station is known to differ from 1/10, or there is reasonable evidence that an individual situation requires a difference ratio, estimate the amount on the basis of available evidence. For example, it may be known that at a particular station 8 inches of snow usually correspond to 1 inch of melted snow; therefore a 1/8 ratio is used. Enter the ratio used and the reasons for its use in block 90 of MF1-10.

Other than determining the vertical depth of the water equivalent of the solid forms, the observer must measure them—especially snow—in their solid state. This is accomplished by thrusting a measuring stick into snow at several places and obtaining an average of all the measurements. If the ground is covered by ice beneath the snow, the observer must cut through the ice, measure the thickness, and add it to the depth of the snow above the ice. The unmelted depth of solid forms that have fallen during the 6 hours ending with the observations is expressed in inches to the nearest tenth of an inch, but the total depth of solid forms on the ground at the time of observation is expressed to the nearest inch.

OBSERVATIONS AND FORMS

A varied assortment of forms are used to record temperature, humidity, and precipitation observations. Some have already been discussed, such as the MF1-10 and NWSC Form 3140/8. The AN/GMQ-29 records rainfall and winds while the AN/GMQ-14( ) records temperature, dew point, and rainfall on recorder rolls. These forms and record rolls and their entries are discussed in the following paragraphs.

MF1-10 and NWSC Form 3140/8 Entries

Entries of temperature, dew point, maximum and minimum temperature, and climatic information are made in accordance with the criteria set forth in the following paragraphs. Again, when this chapter does not cover an aspect of the problem at hand, consult FMH No. 1, Surface Observations.

TEMPERATURE (COL.7).—Temperature is entered to the nearest whole degree Fahrenheit, prefixing a minus sign to a subzero temperature.

DEW POINT (COL.8).—Entered the same as temperature unless the dry-bulb temperature is -35° F or below. Then assume the dew point, with respect to ice, to be the same as the dry-bulb. The water equivalent of this value is computed and then entered in parentheses.

PRECIPITATION (COL.44).—Measurements of all forms of precipitation are expressed in terms of vertical depth of water accumulated within a specified time on a horizontal surface. Enter total precipitation (water equivalent) in inches and hundredths. Also, when:

1. No 6-hour precipitation occurs, enter "0".
2. A trace, but less than 0.005 inch falls, enter "T".
3. No 6-hour precipitation up to the actual observation time, but precipitation was observed prior to coding of the observation, enter "T" even though the amount may be measurable.

If the water equivalent of solid precipitation cannot be measured by melting or weighing of the sample, enter the estimated water equivalent on the basis of the ratio method. For further details, see FMH No. 1.

SNOWFALL (COL.45).—In this column, enter the maximum unmelted depth, in inches and tenths, of solid precipitation that has fallen during the 6 hours ending with the observation. Additional entry instructions are as follows:

1. No 6-hour snowfall, enter "0".

2. A trace but less than 0.05 inch, enter "T" and in block 90, when snowfall melted as it fell, enter also "T—Melted as it fell."

3. If several occurrences of solid precipitation occur in the period, such as snow showers, and each fall melts either completely or partially before the next occurs, enter the total of the maximum depths accumulated by each fall.

4. As a prefix to estimated amounts, enter "E"; in block 90, enter "E—Estimated due to melting."

5. Enter an asterisk (*) as a prefix to HAIL amounts, and in block 90, enter "*HAIL," unless other solid forms of precipitation occurred during the period.

Additional information is contained in FMH No. 1.

SNOW DEPTH (COL.46).—In this column, to the nearest inch, enter in the 6-hourly spaces the depth of solid precipitation and ice on the ground at each 6-hourly observation. Additional entry instructions are contained in FMH-1.

MAXIMUM TEMPERATURE (COL.47).—Enter the maximum temperature in whole degrees Fahrenheit that has occurred in the 6 hours prior to each 6-hourly observation and between midnight and the first 6-hourly observation and between the last 6-hourly observation and midnight, on the line captioned 1,2,3, and 4 and MID TO and MID, respectively.

MINIMUM TEMPERATURE (COL.48).—Entered the same as column 47.

24-HOUR MAX AND MIN TEMPERATURES (COL. 66 & 67).—Col. 66 will be the maximum value recorded in col. 47 for the day. Col. 67 will be the minimum value recorded in col. 48 for the day. Note that the value on the line captioned "1" in cols. 47 and 48 is for a period extending prior to midnight (LST); consequently this value is disregarded in determination of the 24-hour maximum and minimum temperatures.

24-HOUR PRECIPITATION (COL.68).—Enter the total precipitation (water equivalent) for the 24 hours ending at midnight to the nearest 0.01 inch.

24-HOUR SNOWFALL (COL.69).—Enter the total amount (unmelted) of solid precipitation that has fallen in the 24 hours ending at midnight LST.

SNOW DEPTH (COL.70).—Enter the depth of solid precipitation and ice on the ground at 1200 GMT or, in areas other than the contiguous United States, a time modified as necessary to meet regional needs. Entries are made to the nearest whole inch.

PRECIPITATION, THUNDERSTORMS, AND OBSTRUCTIONS TO VISION (COL. 82/86).—Enter form of precipitation occurring at the station. All entries will be in accordance with the appropriate tables in FMH-1 or Table 10-1 of this manual.

BEGAN and ENDED (COL.83 & 84).—Enter the local standard time that the precipitation entered on the same line in column 82/86 began (COL. 83) and ended (COL. 84).

When any of these phenomena is occurring at midnight, enter "Cont." in column 84 for the day ending at midnight, and in column 83 for the day beginning at midnight.

NWSC FORM 3140/8 Entries

SEA WATER TEMPERATURE.—Enter sea surface water temperature to the nearest tenth degree Celsius. Corrected readings from the condenser intake may be used provided such corrections have been determined by a series of comparative bucket-condenser readings for the ship's current speed.

The method for taking bucket observations is explained in FMH No. 1.

AN/GMQ-29( ) and AN/GMQ-14( ), Temperature, Dew-point, and Precipitation Recording Charts

The AN/GMQ-29( ) recording chart records only precipitation and wind (which was discussed in chapter 3), while the AN/GMQ-14( ) records temperature, dew point, and precipitation. The AN/GMQ-29( ) chart should be changed at midnight (LST) on the 1st of every month, and as often thereafter as necessary. The charts should be annotated in accordance with the following:

1. At the beginning and end of each chart enter the station name, date, and time to the nearest minute (LST) when the chart was put on or taken off.
2. Time-check the chart at every 6-hourly observation, with the time to the nearest minute.
3. When the chart is adjusted for time, indicate the adjustment on the chart by entering an arrow at the point of the adjustment and write the time of the adjustment near the arrow.
4. Time check the chart upon notification of an Aircraft Mishap.
5. For each disruption or discontinuity, such as a power failure, equipment failure, etc., enter on the chart at this point the reason and time of the interruption. When returned to service, correct the chart for time and enter a time check. An appropriate entry should also be made in block 90 of MF1-10.
6. Enter a time-check at the first observation of the day at stations not operating 24 hours per day.

THERMOMETERS

Thermometers are classified according to their operating principles and their purpose. In this section only the liquid-in-glass thermometers are discussed.

Liquid-in-glass thermometers are designed on the principle of differential expansion. The fluid used in the thermometer expands and contracts at a different rate than the glass tube it is contained in. By etching an appropriate scale on the tube we can measure this difference in expansion and thereby determine the change in temperature.

STANDARD

The standard air thermometer which you are more than likely familiar with is the one placed inside or outside of the house to see how cold or warm the temperature was during the day or how cool the air conditioner is keeping the house. There are many common uses for this thermometer which is usually filled with either mercury or alcohol depending on its intended use. These two fluids are used because they have a much greater coefficient of expansion for each degree of change in temperature than glass has. (See figure 4-1.)

The range of the standard air thermometer used by the Naval Weather Service is from -20° F to +120° F.

Handle these thermometers carefully; they break easily. It is important that the thermometer stem and bulb be kept clean and free of dirt, dust, and salt spray since the presence of dirt or moisture on the bulb causes an erroneous indication of the free air temperature. Clean the stem and bulb by wiping with a soft cloth. This should be done 10 to 15 minutes prior to taking a reading so the temperature will have time to stabilize before the observation. Remove and clean the metal back as necessary. Upon reassembly apply a drop of light oil to the brass mounting screws. Renew the etched graduations when faded.

To reunite a separated mercury column, attach a psychrometer sling to the thermometer metal back and whirl it, or tap the bulb lightly against the heel of the fleshy part of the hand so as to jar the mercury column back together. If this fails, gently heat the bulb by placing it near a light bulb until the column unites. Never heat the bulb over an open flame. Leave a small space at the top of the tube while heating; otherwise the thermometer will break. If these methods fail to unite the mercury column, then replace the thermometer.

Some isolated stations may still utilize the maximum and minimum thermometers. These are shown in figure 4-2. Procedures for their use and operation are found in the Federal Meteorological Handbook No. 1.

SHELTERS

With the increased use of automatic weather stations, such as the AN/GMQ-29( ) that have self-contained shelters for their sensing elements, the wooden-type shelters are becoming a thing of the past. However, some stations still using the AN/GMQ-14( ) and isolated overseas stations may have the wooden-type shelters still installed. (See figures 4-3 and 4-4.)

These instrument shelters are used to house several meteorological instruments including the psychrometer and the maximum and minimum thermometers.

PSYCHROMETERS

The several types of psychrometers have as their basic construction two thermometers secured as a unit to a metal back or supporting device. They may be hand-held (sling-type and electric) or rotor-mounted instruments.

The primary objective is to obtain the temperature readings of the dry-bulb and the wet-bulb thermometers, and then calculate the difference between the two readings. The difference is called the depression of the wet bulb, which is used to find relative humidity, dew point, and vapor pressure. Observations are interpreted by consulting appropriate psychrometric tables or computers.

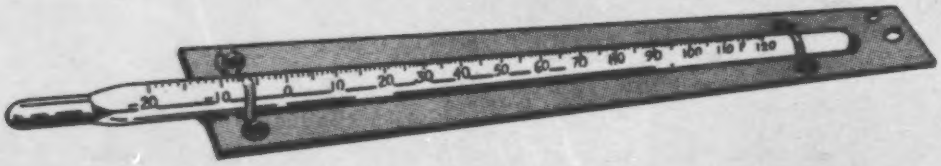


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Figure 4-1.—Standard air thermometer.

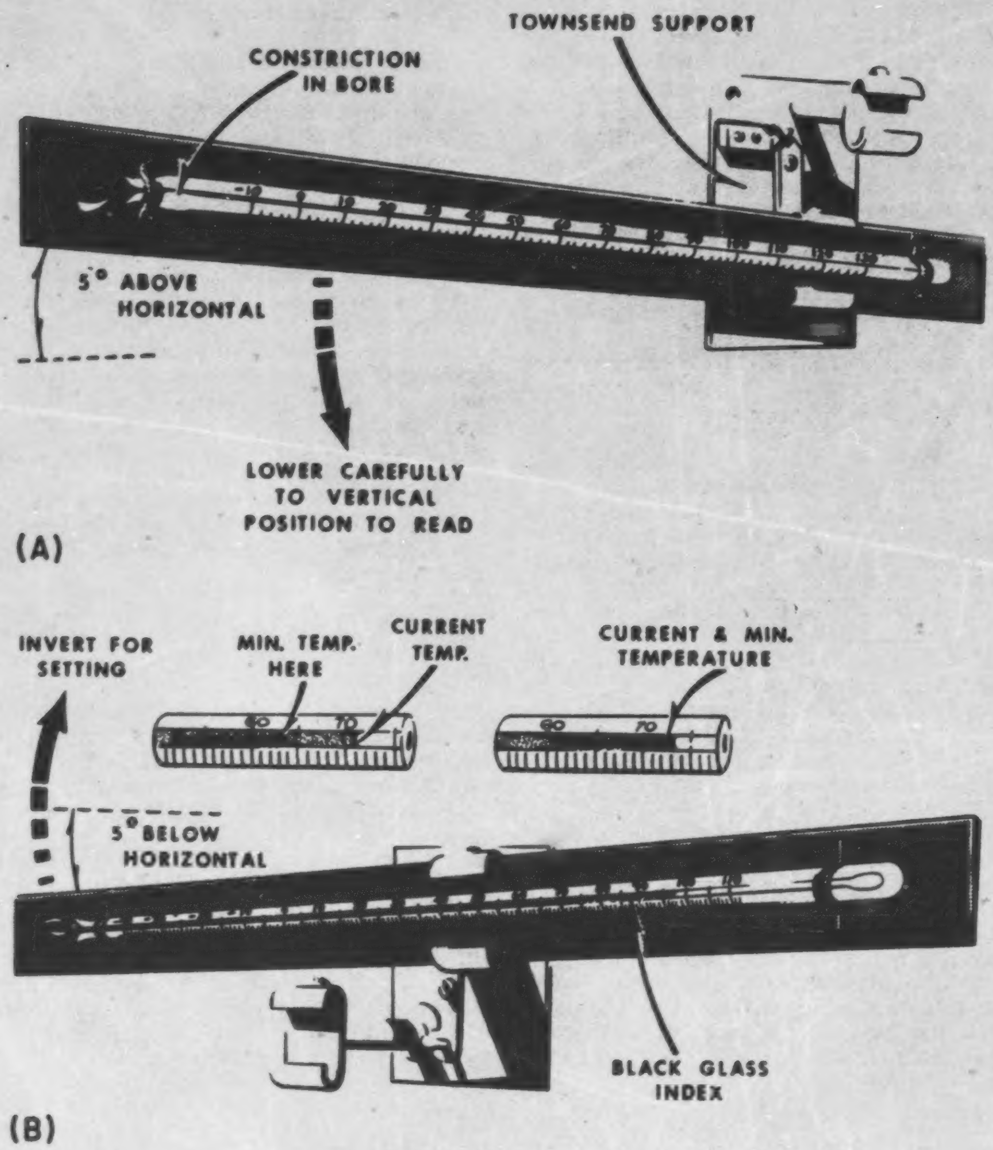
TOWNSEND SUPPORT
CONSTRICTION IN BORE
5° ABOVE HORIZONTAL
LOWER CAREFULLY TO VERTICAL POSITION TO READ
(A)
INVERT FOR SETTING
MIN. TEMP. HERE
CURRENT TEMP.
CURRENT & MIN. TEMPERATURE
60
70
5° BELOW HORIZONTAL
BLACK GLASS INDEX
(B)

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Figure 4-2.—(A) Maximum thermometer (B) Minimum thermometer.

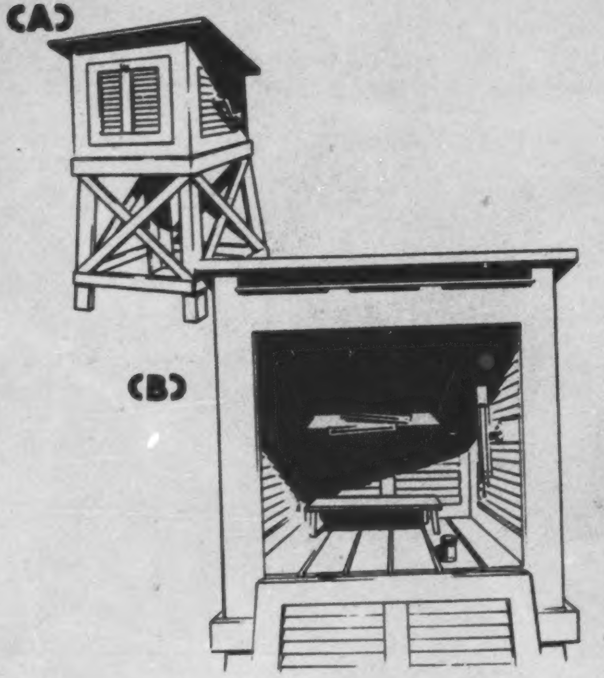

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Figure 4-3.—Standard instrument shelter. (A) Construction of support. (B) Instrument arrangement inside the shelter.

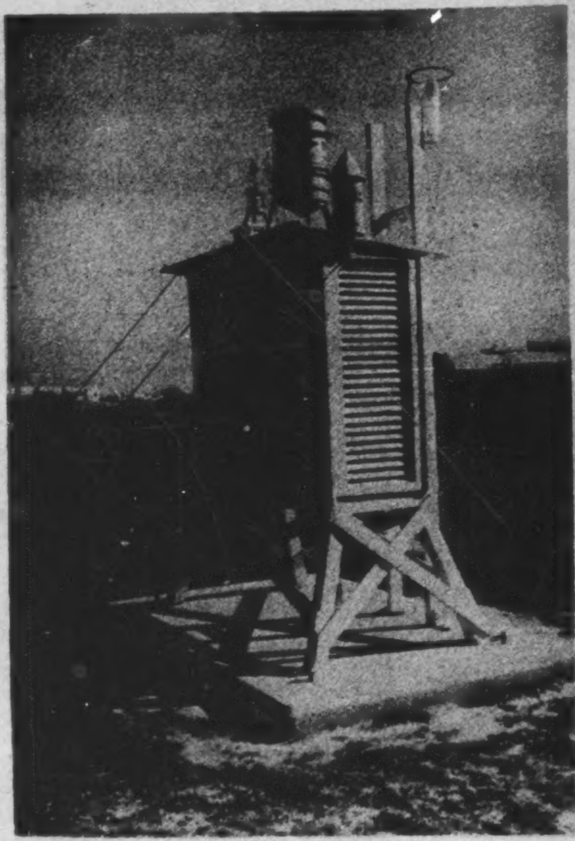

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Figure 4-4.—Shelter used with AN/GMQ-14( ).

SLING

The sling psychrometer, is shown in figure 4-5. The sling consists of a wooden grip with a swivel head and harness-type snap or spring clip for attaching to the top hole of the psychrometer frame.

When not in use, the sling psychrometer should be hung on a suitable hook.

Handle the sling psychrometer carefully at all times. The thermometers are easily broken through careless handling, dropping, or striking some object while being whirled.

For a check on humidity, take it to a clear and open place, preferably exposed to the wind. Never touch the bulb or stem in handling or expose it to the direct rays of the sun while making an observation. The bulb of the wet-bulb thermometer, which is covered with a wick, is moistened with clean water at the time an observation is made. Stand in a clear shady place facing into the wind, and hold the psychrometer as far in front of the body as possible. Rotate the psychrometer with the wrist. Bring the psychrometer to a stop without any sharp jar and bring to eye level. Then read both thermometers to the nearest tenth of a degree, reading the WET-BULB thermometer FIRST. The whirling is repeated, and other readings are made until two successive wet-bulb readings are the same. Amplifying information is contained in FMH-1.

ROTOR

The rotor psychrometer illustrated in figure 4-6 is a psychrometer element secured

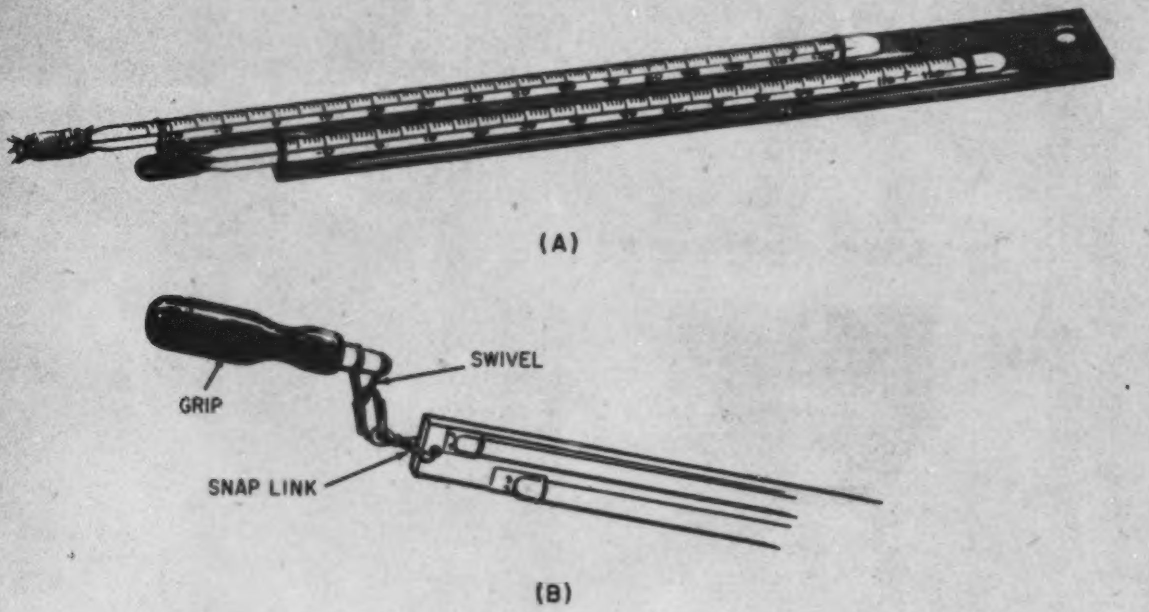

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Figure 4-5.—(A) Standard psychrometer; (B) with sling attached.

to a handcrank-operated shaft. The rotor is designed for wall mounting and permits a permanent installation in the right side wall of the instrument shelter. The same procedure is followed in obtaining a correct reading of the rotor-mounted psychrometer as was given for the sling psychrometer except that the instrument is left in the instrument shelter.

ELECTRIC ML450A/UM

Hand Electric Psychrometer ML-450A/UM is a portable instrument used to obtain free air temperature and the wet-bulb temperature. (See fig. 4-7.)

Although the psychrometer is constructed primarily of noncorrodible materials, prolonged exposure to weathering, salt air, stack gases, and other corrosive elements shorten the useful life of the instrument. The instrument should therefore be sheltered when not in actual use.

The two thermometers comprising the psychrometer have a range from plus 10° F to plus 110° F. The psychrometer comes with a carrying case and three water bottles. With the exception of the three standard flashlight batteries which supply the power, it is ready for operation as issued. (See fig. 4-6.)

Maintenance

Hand Electric Psychrometer ML-450A/UM requires very little maintenance. For proper operation, the instrument should be kept free of dirt and other foreign matter.

When the instrument is not to be used for a prolonged period of time, remove the batteries from the case because batteries will corrode and damage the instrument.

When cleaning the instrument, wash all plastic parts with a mild soap and warm water; rinse with clear water and dry. Wash the thermometers with a mild soap and warm water; rinse with clear water and dry. Wipe electrical contacts with a clean lint-free cloth. If necessary, fine sandpaper may be used to remove

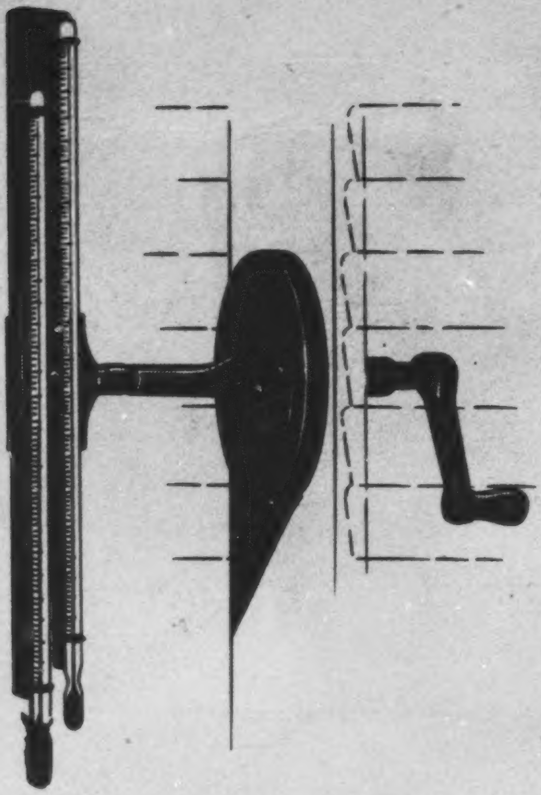

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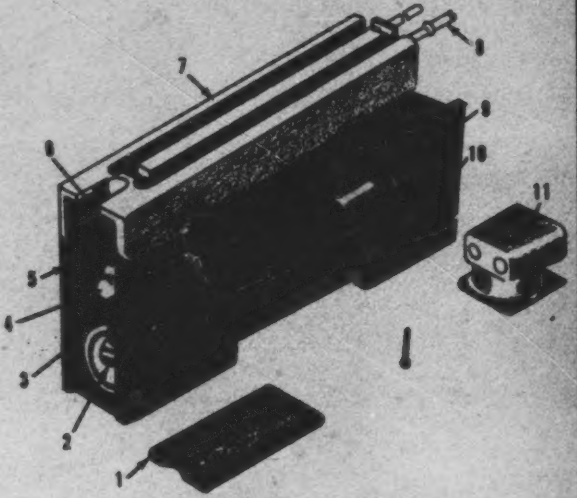
Figure 4-6.—Rotor psychrometer.



1. Sliding door.
2. Spring contact.
3. Battery compartment.
4. Water bottle.
5. Bottle compartment.
6. Hinge pin.
7. Thermometer holder.
Wet-bulb wick.
9. Knob.
10. Exhaust ports.
11. Sliding air intake.

209.116
Figure 4-7.—Hand electric psychrometer ML-450A/UM.

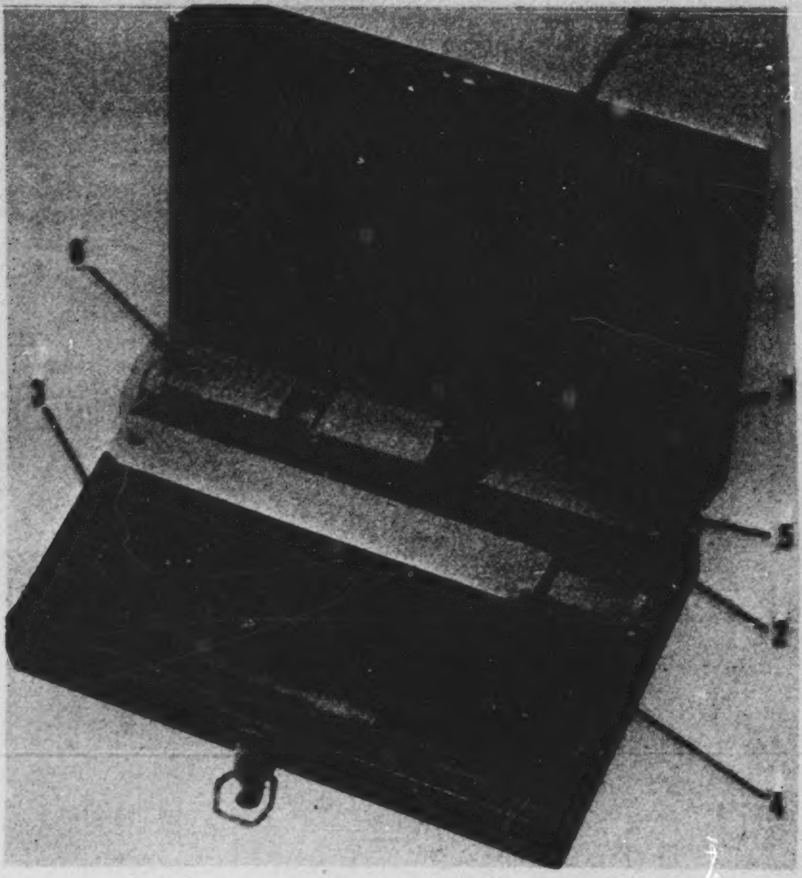
corrosion or pitting. No lubrication is necessary for this instrument; no special tools are required for its overhaul.

BATTERIES.—Three size D (standard flashlight) dry cell batteries are required. To insert the batteries, remove the sliding door at the end of the case and rotate the spring contact from the battery compartment to the bottle compartment.

The batteries must be inserted so that the center contact enters the compartment first. After the batteries are in place, rotate the spring contact to its original position on the end battery and replace the sliding door.

REPLACING THE WICK.—To replace the wick, first remove the sliding air intake exposing the thermometer bulbs. Then remove the wick. Slip a length of wicking over the bulb. Secure at the top of the bulb with a thread at the constriction between the bulb and the stem, using a loop and square knot. Form a loop in a second thread and place it at about the middle of the bulb, stretching the wick firmly and snugly against the bulb. Tie with a double loop and square knot at the end of the bulb. Clip the ends of the thread and cut off the excess wicking about one-eighth inch below the bottom of the bulb.

REMOVING AND REPLACING THERMOMETERS.—If either thermometer is damaged, it is necessary to remove both thermometers and replace them with a matched pair. To remove and replace the thermometers, first remove the air intake and the thermometer



1. Neck strap.
2. Spare thermometers.
3. Psychrometer.
4. Instructions and tables.
5. Box (extra wick, thread, and lamp).
6. Two-ounce bottle.
7. Carrying case.

209.117

Figure 4-8.—Hand electric psychrometer in carrying case.

retainers. Then lift out the thermometers. Remove the rubber bushings from the bulb ends of the thermometers and the bushings from the other ends of the thermometers.

Place the longer bushings on the bulb end of the new thermometers so they are flush with the end of the thermometer holder. This seals the small holes in the air intake when it is slid into position.

CAUTION: Position the rubber bushings on the thermometer so the retaining clamps rest on them. Otherwise, the pressure of the retaining clamps may break the thermometers.

Replace the thermometers, positioning them so the graduations are visible and both mercury columns are magnified when viewed from the same position. Replace and tighten the thermometer retaining clamps.

REUNITING MERCURY COLUMN.—If the mercury column of either thermometer separates, an effort should be made to reunite the mercury column. To do this, remove the thermometer as described earlier. Gently heat the thermometer bulb under a light bulb to gradually force the mercury to the top of the tube. Care must be taken so the mercury does not cause the thermometer to burst. Upon cooling, the mercury should recede as a united column.

REPLACING THE LAMP.—To replace a lamp, first remove the sliding air intake and retaining screw that keeps the thermometer holder in the correct position. Then raise the unrestrained end of the thermometer holder upward to provide access to the lamp. Finally, remove the red filter and change lamps, replace the filter, and secure the thermometer holder; replace the air intake.

INSPECTIONS.—Inspect for cracks or breaks in the plastic parts. Inspect threaded holes and screws for wear, and the fan for damage. Inspect the thermometers for cracks and separated mercury columns. Inspect the carrying case for damage, and the motor shaft for smoothness of rotation.

REPAIR OR REPLACEMENT.—All plastic parts that are broken, cracked, or have missing or damaged threaded inserts should be replaced. Damaged screws should be replaced. If the motor shaft does not turn freely or if the fan is damaged, the motor and fan assembly should be replaced. If the contacts on the contact block do not contact the motor terminals correctly, they should be carefully bent so that good electrical contact is ensured. A carrying case that is damaged beyond use should be replaced.

SEMIAUTOMATIC AND AUTOMATIC WEATHER STATIONS

The AN/GMQ-29( ) is scheduled to completely replace the AN/GMQ-14( ). Because of the lengthy installation period, both the AN/GMQ-14( ) and the AN/GMQ-29( ) are discussed in this manual.

AN/GMQ-14( )

Semiautomatic Meteorological Station AN/GMQ-14( ) is an electromechanical instrument system with facilities to house, sense, and record temperature, dew point, precipitation, pressure, and wind. (See fig. 4-9.) Barometer ML-448/UM and the Marine Barograph are covered in chapter 2 of this training manual. Wind Recorder RD-108( )/UMQ-5 is covered in chapter 3, along with the AN/UMQ-5( ) wind system.

This station includes a rain gage; a DEWCEL (dew point sensing element) housed in a shelter; a dewcel power supply; a dew point transmitter; an air temperature bulb; and air temperature transmitter; an equipment rack containing a combined rainfall, dew point, and temperature recorder; a 24-hour clock; a junction box; and a test cord.

Three systems in the semiautomatic meteorological station are covered in this chapter. They are the dew-point measuring and recording system, the air temperature measuring and recording system, and the rainfall gaging and recording system discussed under rain gages.

Dew-point Measuring and Recording System

The dewcel, covered with woven glass tape impregnated with lithium chloride and wrapped with gold or silver wires, measures the dew-point temperature.

The current for the dewcel passes through the dewcel power supply, consisting of a step-down transformer and an incandescent lamp used as a ballast resistor. The dewcel actuates the temperature element in the transmitter assembly.

Air Temperature Measuring and Recording System

The temperature measuring and recording system operates similarly to the dew-point measuring and recording system. Instead of the dewcel, a temperature bulb is used and no separate power supply is required. The temperature bulb is similar to the dewcel minus the glass tape and wire wrappings. The signal is recorded by the center pen on the right half of the chart.

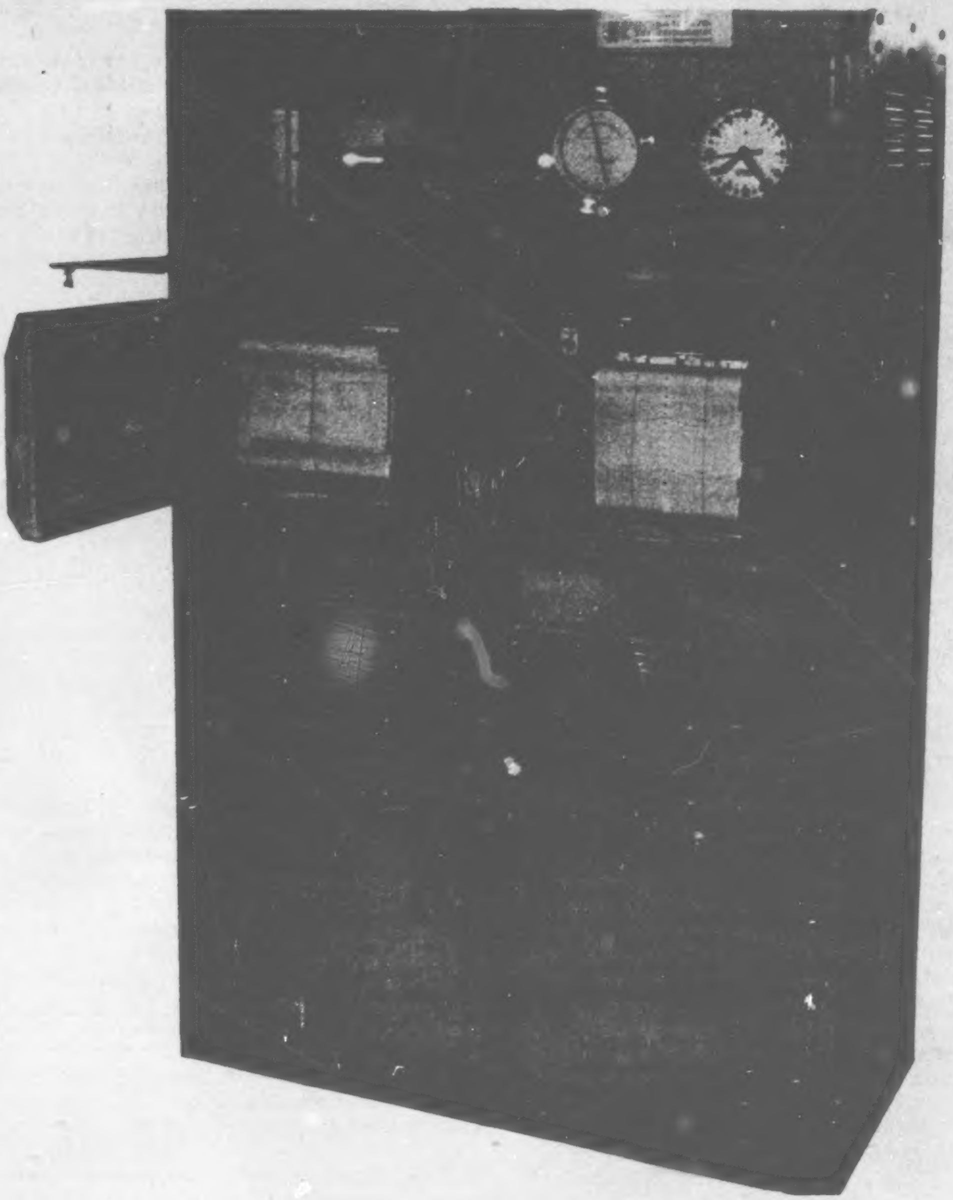


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Figure 4-9.—Semiautomatic meteorological station AN/GMQ-14( ).

Recorder and Case Assembly

The recorder and case assembly is a convenient means of combining in a single assembly the receivers, recorders, and power controls for the three systems. A synchronous motor drives the chart. One ink reservoir supplies the air temperature and dew-point recording pens. The rainfall recording pen has an independent ink reservoir. The power input for all three systems as well as for the recorder is in the recorder case assembly and is designed for 115-volt, 60-cycle, ac. The power switch for the three systems, the recorder lights switch, and the chart drive speed switch are also in the recorder case.

Operation

As its name indicates, the semiautomatic meteorological station requires a minimum of operating procedures. The main switch, governing the recorder and the three systems, is at the front of the recorder case at the left side. Placing it ON provides current for the recorder, the transmitters, the rain gage, and the dewcel power supply. The transmitters operate automatically as soon as current is supplied to them. The only operation required for the rain gage is emptying the measuring cylinder.

FILLING INK RESERVOIRS AND PENS.—Ensure that the main power switch is turned OFF. Lift the pens from the chart by using the pen lifter; then remove the pens by lifting them straight up and out of their carriage slots. Lift the reservoirs out of the recesses in which they are located. Be careful not to spill any of the remaining ink on the recorder, as removal of the ink is difficult. Fill the reservoirs about three-fourths full of ink. Carefully replace the reservoirs in the recorder. Place the pens in the slots in their respective carriages. Using a common soda straw, fold the end over and pierce a small hole with a pin about one-fourth inch from the folded end. Insert the pen tip in this hole and suck on the open end of the straw until ink is drawn through the pen tube into the straw. The translucent material of the straw allows the operator to see when ink is entering from the pen. Remove the straw.

Maintenance

Inspect all wiring periodically to ensure that electrical lines are intact. Set up inspection periods commensurate with existing climatic conditions. Visually inspect all housings or casings for corrosion or deterioration. Refer all other maintenance problems to your supervisor. Maintenance beyond operator maintenance is not the responsibility of the Aerographer's Mate.

RECORDER.—Replace the light bulb as required. Visually inspect pens to see that they are not bent or distorted. If distortion can be corrected by straightening the pen manually, bend it into shape. If the distortion cannot be corrected by straightening the pen manually, remove and replace the pen. Never allow the pens to dry out with ink in the bore. Clean the pens and reservoirs periodically, determining the periods on the basis of existing climatic conditions. A piece of music wire is furnished for cleaning the bore of the pen tips if they become clogged.

CLEANING THE PENS AND RESERVOIRS.—Chart lint should be wiped from the pen tips if a fuzzy or broad line indicates that lint is present. If the system is to be shut down or unused for extended periods of time, empty the reservoirs and wash them with clear water. Ink can be cleaned out of the pens by holding them so that a moderately strong faucet stream is directed to the reservoir end of the pen tube. If the force of the water is insufficient to flush out the pens, use an ordinary ear syringe filled with water inserted at the reservoir end of the pen tube. Blow the water out of the pens after they are flushed.

PERIODIC INSPECTION OF RECORDER.—Inspect the record chart daily for a clear legible record trace, proper time setting, sufficient chart reserve, takeup without binding, and agreement of recorded values with the indicator readings.

Inspect the pens daily for evidence of clogged ink, fuzzy line on the record, and recording on sudden swings.

Inspect the ink tanks weekly to see that sufficient ink is in the tanks.

AN/GMQ-29( )

The AN/GMQ-29( ) Automatic Weather Station, figure 4-10, accumulates and displays meteorological data for support of air station operations and for use in forecasting. It is intended for installation at air stations where sensing equipment can measure weather conditions at or near the runway area and transmit the data gathered over a single audio channel to the operations area for display.

The station consists of two major components. The first is the sensor group with meteorological sensors and data transmission electronics. The second is the Converter Display Group, with data reception electronics, digital displays, and chart recorder. (See figure 4-11.)

Description of Components

The sensor group consists of the signal conditioner, transmitter, and the meteorological sensors. The conditioner, transmitter, and barometric pressure sensor ML-642/GMQ-29( ) are housed in a weatherproof cabinet upon which some components are mounted. The other sensors are located as follows.

AIR TEMPERATURE SENSOR (ML-641/GMQ-29( )).—This sensor consists of a resistance element probe mounted in an enclosure which provides solar radiation shielding and protection from precipitation while permitting a free flow of air. (See figure 4-12.) The air temperature sensor is normally mounted within 15 feet of the transmitter.

DEW-POINT SENSOR (ML-643/GMQ-29( )).—The dew-point sensor is a heated resistance probe installed in a chamber which permits adequate self aspiration while protecting the sensor from solar radiation, wind, and rain. (See figure 4-13.) Normal installation of the dew-point sensor is within 15 feef of the transmitter.

RAINFALL SENSOR (ML-558/GMQ-14( )).—This system is discussed later in the chapter under rain gages.

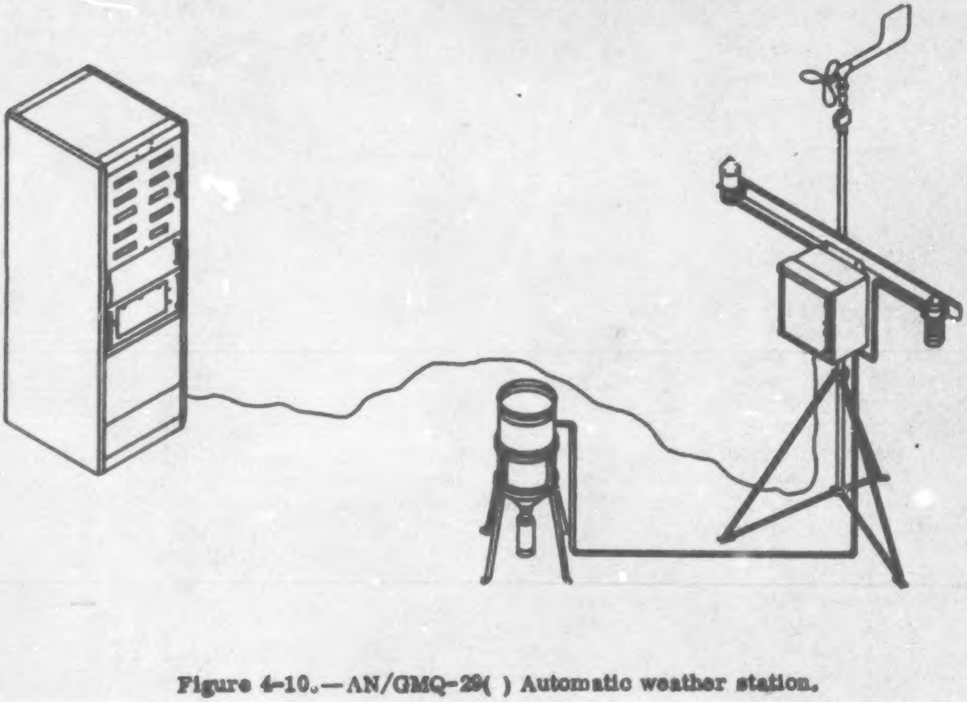

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Figure 4-10.—AN/GMQ-29( ) Automatic weather station.

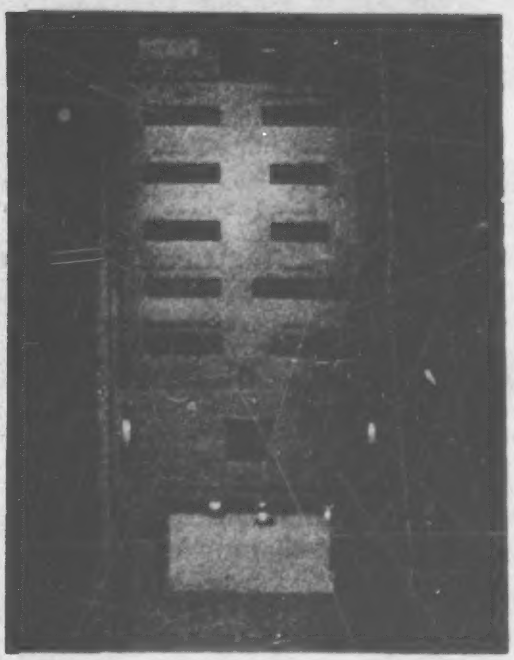

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Figure 4-11.—AN/GMQ-29( ) Converter display group.

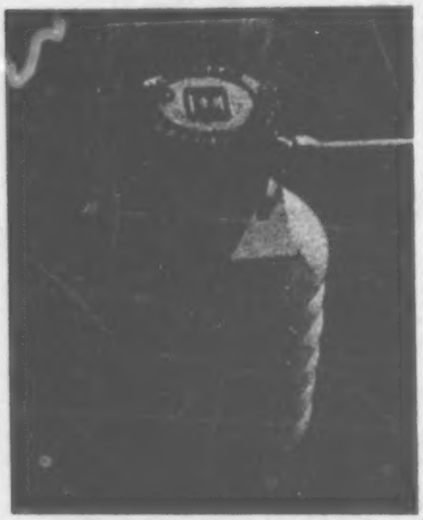

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Figure 4-12.—Air temperature sensor ML-641/GMQ-29( ).

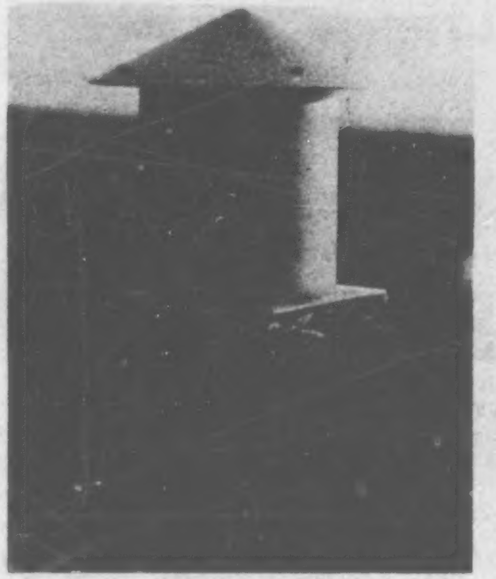

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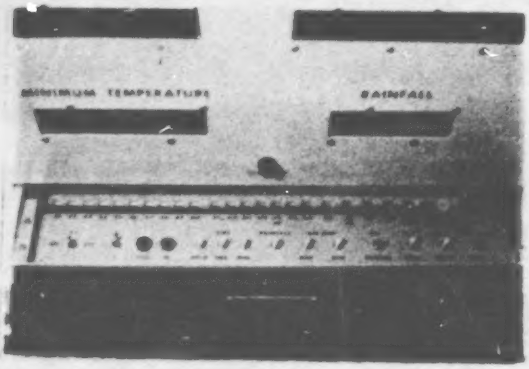
Figure 4-13.—Dew point sensor ML-643/GMQ-29( ).

DATA RECEIVER AND CONTROL ASSEMBLY.—This unit is contained in a slide-mounted drawer which provides access to all parts of the assembly from the front of the display unit. Contained within the drawer are the display station power supply, electronic equipment for data reception and computations, and the control panel. (See figure 4-14.) Data electronic equipment is contained in a circuit card cage. Also included are a time-of-day clock module and an internal digital voltmeter. The control panel, mounted just inside the drawer, has provision for control of power, selection of system calibration, setting of the time clock, resetting stored maximum and minimum temperatures and rainfall, and digital input and control.

READOUT PANEL.—The readout panel contains digital displays for time of day, temperature, dew point, maximum and minimum temperatures, wind speed (averaged), wind direction (averaged), and the digital voltmeter. (See figure 4-15.) Each display consists of sufficient digital readout lamps to display the data.



209.397
Figure 4-14.—Data receiver and control assembly.

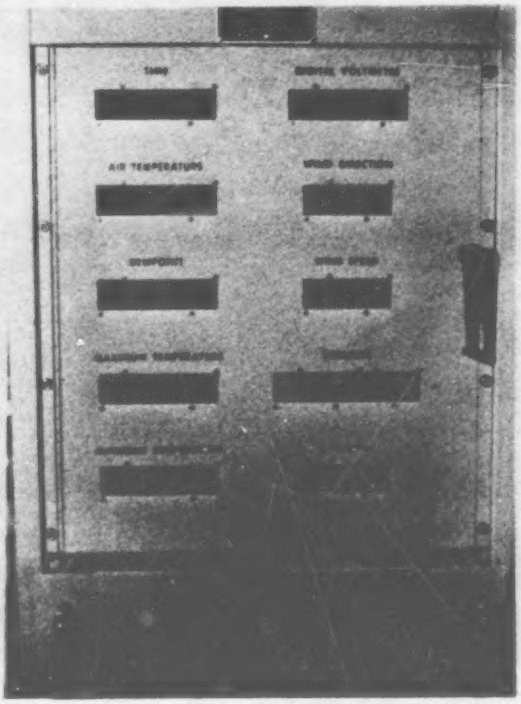
ANALOG RECORDER (RO-447/GMQ-29( )).—Mounted directly below the Data Receiver and Control Assembly, it is used to record wind direction and speed (discussed in chapter 3 of this manual; see figure 3-4) and precipitation to be discussed later in this chapter under rain gages.

INTERCOMMUNICATIONS GROUP (OA-8785/GMQ-29( )).—At selected installations the AN/GMQ-29( ) is equipped with a voice channel, which provides for use of the existing transmission lines for the additional purpose of full duplex voice communications between remote and local stations.

Theory of Operation

Functional operation of the Automatic Weather Station AN/GMQ-29( ) is dependent upon the following principles. Individual sensor outputs are converted by their associated signal conditioners to voltage levels. Timing and control circuits then control data transmission over a single telephone line to the data receiver. Rainfall information, is accepted by the formatting circuitry directly from its signal conditioner. At the display unit, the data is received, its validity verified and then routed to appropriate internal destinations for computations, recording, and display.

For a more detailed description of the AN/GMQ-29( ) Automatic Weather Station, refer to NAVAIR 50-30GMQ-29-1, Handbook, Operation, Service and Overhaul Instruction.



209.398
Figure 4-15.—AN/GMQ-29( ) Readout panel.

Maintenance

Although most maintenance is performed by the electronic technicians, some maintenance can be performed by the Aerographer's Mate. This includes the visual inspection of the equipment. Refer to Table 14-1 for a complete inspection list. If no electronic technicians are attached to the unit, refer to NAVAIR 50-30GMQ-29-1 for guidance in mechanical maintenance, minimum performance checks, and symptom troubleshooting.

RAIN GAGES

Precipitation measurements are made from samples caught in gages, or from samples taken from representative areas when the catch of solid forms in the gage is not representative.

FOUR (4) INCH GAGE

The nonrecording plastic rain gage consists of a 4-inch diameter collector ring and

Table 4-1.—AN/GMQ-29( ) Maintenance visual check list

STEP	PROCEDURE	NORMAL INDICATION	IF INDICATION IS ABNORMAL
		SENSOR GROUP	
1.	Visually inspect remote unit enclosure.	Compartment free of moisture, seal firm and resilient. Fasteners intact and free to operate. Sealed cable entries tight.	Replace gasket seal and fasteners as necessary. Reseal cable entries as required.
2.	Visually inspect card cage and power supply	Individual modules/components intact. All wiring firmly connected. Hardware free of corrosion. Fuses good.	Reseat loose modules/components. Secure wiring. Remove corrosion. Replace fuses as necessary.
3.	Inspect Barometric Pressure Sensor.	Sensor fastened tightly to mounting plate. Connections tight.	Secure loose nuts. Tighten connections.
4.	Visually inspect Air Temperature Sensor.	Cable connection tight. Enclosure free of corrosion. Sensor firmly mounted.	Seal cable connection as required. Remove corrosion. Tighten sensor mount.
5.	Visually inspect Dewpoint Sensor.	Cable connection tight. Enclosure free of corrosion. Sensor firmly mounted.	Seal cable connection as required. Remove corrosion. Tighten sensor mount.
6.	Verify Wind Set AN/UMQ-5 ( ) is operating properly.	Refer to NAVWEPS 50-30FR-525.	
		Cable connection tight.	Reseat cable connection as required.
7.	Visually inspect Rainfall Sensor.	Sensor free of corrosion. Tipping bucket operates freely. Water compartment free of dirt and particles.	Remove corrosion. Free tipping bucket of obstructions. Clean water compartment.
		CONVERTER, DISPLAY GROUP	
8.	Visually inspect electrical cabinet.	Clean with no dents or chipped paint.	Remove dents. Retouch painting.
9.	Visually inspect Read-out Panel Assembly.	Door opens and closes securely. All connectors tight. All modules seated properly. Cable harness secure. Plastic lens intact and clean.	Adjust door catch. Seat all modules and connectors. Secure cable harness. Clean all dirty lens.
10.	Visually inspect Receiver and Control Assembly.	Handles latch securely. Drawer opens and closes freely. Module cards securely seated. Harness free from obstruction. Fuses good. Drawer free from dust and dirt.	Adjust handle latch. Remove obstructions from door slides. Securely seat module cards. Secure cable harness. Replace fuses as necessary. Clean where necessary.
11.	Visually inspect Analog Recorder.	Chart paper properly installed. Pens in good condition. Ink assembly not leaking.	Load chart paper correctly. Replace defective pens. Replace defective ink assembly.
12.	Visually inspect Voice Link, if included at station.	Telephone in place in good physical condition.	Replace defective telephone.

funnel, which fit over the top of a tripod-mounted overflow container, and a clear plastic measuring tube. The rainfall drains from the collector ring through the funnel into the measuring tube, which has graduations in the wall for direct reading to the nearest hundredth of an inch. (See fig. 4-16.)

The procedures for taking the measurements were discussed earlier in the chapter.

The only maintenance required for the standard 4-inch rain gage is to keep it clean at all times and make sure it is mounted firmly.

TIPPING BUCKET RAIN GAGE

The tipping bucket rain gage ML-558 (fig. 4-17) was originally designed for use with the AN/GMQ-14( ) Semiautomatic Meteorological Station but has been adapted for use with the AN/GMQ-29( ) Automatic Weather Station.

Operation

A tipping bucket rain gage is mounted in a housing which permits rain to fall directly on the gage. The tipping bucket is a two-compartment container (fig. 4-18) which pivots within a casting. Rainfall enters through the upper funnel in the housing into one compartment of the bucket until 0.01 inch of rainfall has accumulated. The weight of this amount of rain unbalances the bucket, causing the unit to tip on its pivots, dumping the accumulated rainwater, and moving the other compartment directly under the funnel.

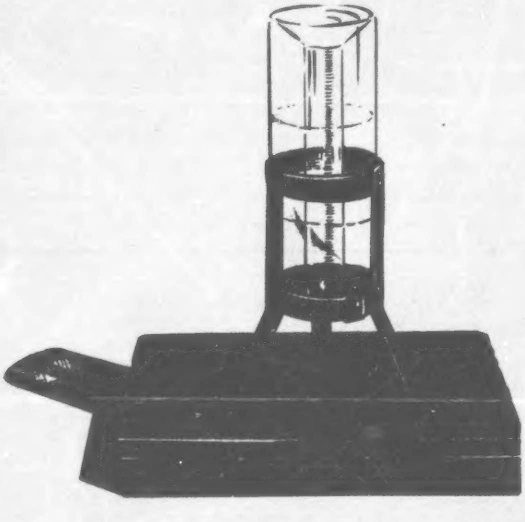


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Figure 4-16.—Standard 4-inch rain gage (ML-217).

209.400
Figure 4-17.—Tipping bucket rain gage ML-558.

When the bucket tips, its rainfall content falls into a funnel beneath the bucket. At the base of the funnel is a drain cock, which in its closed position permits the rain to collect so that it may be drained into the cylinder below the funnel at the time of measurement. If no purpose in measuring the rainfall at a given time exists, the drain cock may be left open and the cylinder removed.

The tipping motion of the bucket actuates a mercury switch in the casting. Momentary

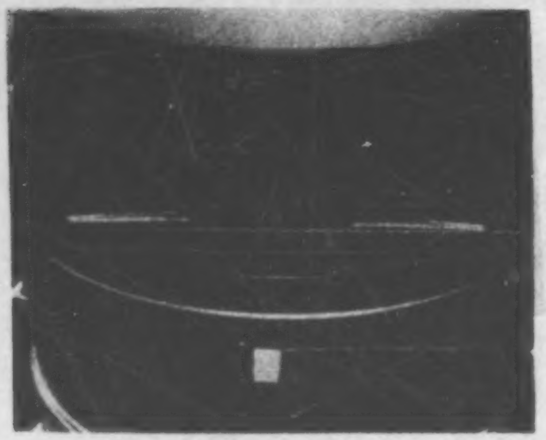

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Figure 4-18.—Tipping bucket rain gage, with door open showing the two-compartment tipping bucket on its pivot.

contact is established within the switch, causing an electrical impulse to be sent to the AN/GMQ-14 recorder, thereby tripping a relay. Each time the signal is received, the rainfall counter registers the 0.01 inch of rain, and the rainfall recording pen at the right side of the recorder moves laterally one step. The pen has a range limit of five steps before reversing its direction of motion.

The AN/GMQ-29( ) presents both a digital display and recorded trace of rainfall. The tipping motion switch closures provide pulses to be counted and stored in the rainfall signal conditioner for each .01 inch of rainfall that occurs during the data frame (time period). The content of the counter is transferred to the display on command of the data transmitter. The contents are used to update the rainfall digital display and totalizer counter. The Analog Recorder RO-447/GMQ-29( ) (discussed earlier in chapter 3) is used to record the rainfall amounts. It is recorded on the right side margin of the chart and as an event marker to the left for each 0.01 inch of rain, with every tenth mark (0.01 inch) reversing direction and recording a mark to the right.

Maintenance

Inspect the tipping bucket assembly and the measuring cylinder for corrosion or deterioration. Ensure that the bucket moves freely within the casting in which it is installed. When replacing the bucket, ensure that the magnet mounted on the tipping bucket is toward the mercury switch (away from the inspection door).

OCEANOGRAPHIC TEMPERATURE SENSORS

Sparseness and inaccuracy of data are among greatest difficulties to be overcome in attempting to prepare accurate oceanographic forecasts. To aid in obtaining this data, numerous pieces of equipment have been designed to sense the ocean temperatures, both at the surface and below it. The Aerographer's Mate generally does not operate these equipments, but may come into contact with them on occasion.

A brief résumé of the types of oceanographic sensors and their functions are described in the following paragraphs.

NON-CONTACT SENSORS

One way of oceanographic data sensing is the non-contact method. This method obtains the sea surface temperature by use of infrared equipment, such as the Portable Radiation Thermometer PRT-4( ). It is designed to measure the infrared radiation from surfaces which are difficult or impossible to measure by conventional methods because of physical location or other restrictive conditions.

Another infrared device is the Airborne Detection Thermometer. This is a completely self-contained, non-contact airborne radiation thermometer which automatically measures and records the surface temperature of the sea.

CONTACT SENSORS

The second way to obtain oceanographic data is the contact method. Both the airborne and shipboard bathythermograph are used for this method. These sets automatically obtain and record ocean temperature data by the use of expendable probes that are ejected from the ship or aircraft. This ship version will return a temperature profile to a depth of 1,500 feet while the aircraft only returns a 1,000-foot temperature profile. Both profiles are depicted on a recorder mounted in the ship or aircraft.

For more information on these various oceanographic temperature sensing equipments, refer to the appropriate technical manuals.

NOTE: Changes to all column numbers and entries on NWSC Form 3140/8 were received too late for inclusion in this manual. Where errors in column numbers appear, refer to the U.S. Navy Supplement to FMH #1, Chapter 13, Marine Aviation Observations for the most recent amplifying instructions.

CHAPTER 5

CLOUDS AND VISIBILITY

This chapter will familiarize the Aerographer's Mate with the definitions of clouds and visibility, including the methods and equipment used to determine these important weather elements. Detailed descriptions on types of clouds and their structure is presented in chapter 15. The basic reference for cloud observations, classification, and identification, is the International Cloud Atlas, NA 50-1D-509. Frequent reference should be made to this atlas when determining cloud data.

CLOUDS AND VISIBILITY

Of all the weather conditions adversely affecting aircraft operations, low ceilings and low visibilities are by far the most common. They are the cause of most of the flight delays and cancellations due to weather.

"Ceiling" and "visibility" are two terms that are fundamental in aviation terminology and are probably used more than any others in describing flying weather. Seldom does a pilot check on the flying weather without paying particular attention to these conditions since visibility, together with ceiling, holds the answer to many flight problems.

DEFINITIONS

Clouds are defined as a visible aggregate of minute particles of water or ice, or of both, in the free air. It may also include larger particles of water or ice, and particles such as those present in fumes, smoke, or dust. Clouds are further defined in ceiling and sky conditions as follows:

1. Layer. Clouds or obscuring phenomena whose bases are at approximately the same level are regarded as a layer. The layer may be continuous, or it may be composed of detached elements. The term "layer" does not imply that a clear space exists vertically between layers or that clouds or obscuring phenomena composing them are of the same type. The only requirement of composition is that all the elements of the layer are based at approximately the same level.

2. Obscuration. The term ' obscuration" is used to denote that an observer at the surface is unable to evaluate the sky condition aloft in the usual manner because surface-based obscuring phenomena (fog, smoke, etc.) hide more than 9/10 of the sky, as determined to the nearest tenth. (See fig. 5-1 (A).)

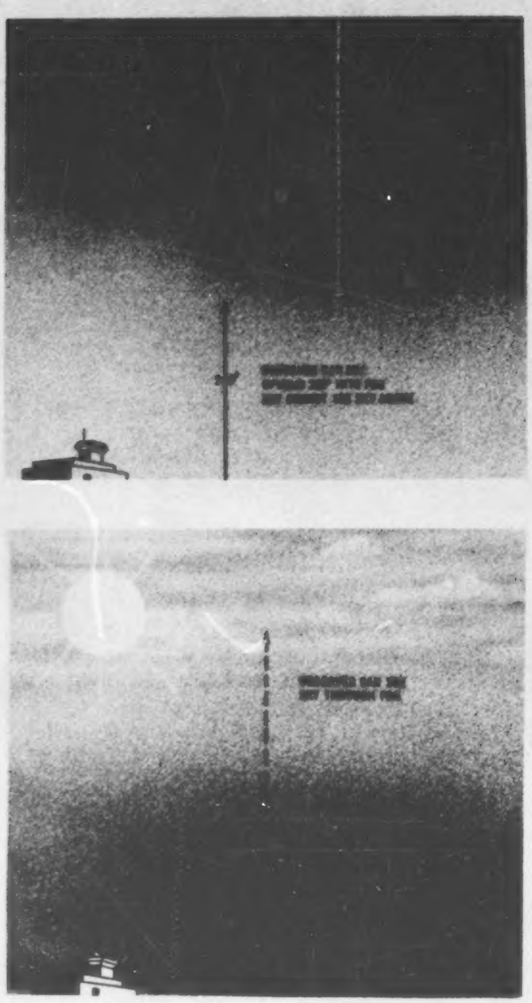
3. Partial obscuration. The term partial obscuration is used to denote that 1/10 or more of the sky (to nearest tenth), but not all of the sky is hidden by surface-based obscuring phenomena. Normally the phenomena is uniformly distributed. (See fig. 5-1 (B).)

4. Transparency and opacity. As used in this training manual, transparency and opacity of cloud layers or obscuring phenomena are defined as follows:

a. Transparent sky cover. Those portions of cloud layers or obscurations which do not hide the sky. Blue sky or higher clouds can be discerned through these portions during daylight, and the moon and brighter stars may be discerned at night.

b. Opaque sky cover. Those portions of cloud layers or obscurations which hide the sky and/or higher clouds. Translucent sky cover which hides the sky but through which the sun and moon (not stars) may be dimly visible will be considered as opaque.

5. Thin sky cover. A term applied to a layer when the ratio (of summation amounts



209.213
Figure 5-1.—(A) Sky completely hidden by fog; (B) sky partially obscured by fog.

at and below the level of the layer) of transparent to total sky cover is 1/2 or more.

6. Surface. For height determinations, the term "surface" means the horizontal plane whose elevation above sea level equals field elevation. At a station where the field elevation has not been established, the term "surface" refers to ground elevation at the point of observation.

7. Ceiling. The ceiling is the height ascribed to the lowest opaque layer of clouds or obscuring phenomena aloft that is reported as "broken" or "overcast."

For an obscuration, a ceiling value represents vertical visibility in a surface-based phenomenon associated with an obscured sky.

The ceiling is termed "unlimited' when the foregoing conditions are not satisfied.

8. Vertical visibility. Vertical visibility is a ceiling value used to express the distance that an observer at the ground in an obscuring medium can see vertically upward into the medium, or the maximum vertical height above the ground at which a pilot in surfaced-based obscuring medium can recognize the ground.

9. Variable ceiling. A term that describes a condition in which the ceiling rapidly increases and decreases by one or more reportable values while the ceiling observation is being taken.

10. Visibility is defined as the greatest distance at which selected objects (visibility markers—dark or nearly dark objects viewed against the horizon sky) during the day, or unfocused lights of moderate intensity (approximately 25cd) during the night, can be seen and identified.

DETERMINING CLOUDS AND VISIBILITY

Clouds

The weather observer should take several factors into consideration when evaluating sky cover (clouds and obscuring phenomena)—determination of the sky cover's stratification; amount of sky cover; direction of movement of the clouds; height of the bases of the clouds; and the effect of obscuring phenomena on the vertical visibility. Observation of these elements should be taken from as many points as necessary to view the entire sky.

Determination of Stratification

The observer should first determine how many layers of clouds or obscuring phenomena are present at the time of the observation.

Frequent observation is necessary to evaluate stratification. A series of observations often show the existence of upper layers above a lower layer. Through thin lower layers it may be possible to observe higher layers. Differences in the directions of cloud movements are often a valuable aid in observing and differentiating cloud stratification, particularly when haze, smoke, etc., render depth perception difficult.

Cumulo-type clouds developing below other clouds may reach or penetrate them. Also, by horizontal extension, swelling cumulus or cumulonimbus may form stratocumulus, altocumulus, or dense cirrus. When clouds formed in this manner are attached to a parent cloud, they are regarded as a separate layer only if their bases appear horizontal and at a different level from the parent cloud. Otherwise, the entire cloud system is regarded as a single layer at a height corresponding to that of the base of the parent cloud.

Sky Cover Amounts

Sky cover amounts are evaluated with reference to the entire sky above the local (apparent) horizon rather than the celestial horizon; in terms of the amount of sky covered, or hidden (to the nearest tenth) as viewed by an observer on the earth's surface.

Evaluations are made of the following:

1. Amount of sky hidden by surface-based atmospheric obscuring phenomena, such as fog, smoke, haze, precipitation, etc.

2. The amount of sky covered but not necessarily hidden by clouds and/or obscuring phenomena in each layer aloft.

3. Amount covered or hidden by a combination of 1 and 2.

4. Layers reportable as being thin.

There are various methods of estimating the amount of sky cover. The procedure is simplified if the sky cover consists of an advancing or receding layer, or a continuous layer surrounding the station.

To estimate the amount of an advancing or receding layer, determine the angular elevation above the horizon of the forward or rear edge of the layer as seen against the sky. Use a clinometer until experience is gained in estimating vertical angles. Convert the angle to tenths of sky cover. (See table 5-1.) When the layer does not extend to the horizon, determine the angular elevation of

Table 5-1.—Sky cover evaluation

Angle of Advancing or Receding Layer Edge	Tenths of Sky Cover	Angular Elevation of Layer Surrounding Station
0° to 25°	0	0° to 2°
26° to 45°	1	3° to 8°
46° to 59°	2	9° to 14°
60° to 72°	3	15° to 20°
73° to 84°	4	21° to 26°
85° to 95°	5	27° to 33°
96° to 107°	6	34° to 40°
108° to 119°	7	41° to 48°
120° to 134°	8	49° to 58°
135° to 154°	9	59° to 71°
155° to 180°	10	72° to 90°

Table 5-2.–Sky cover contractions

Summation Amount of Sky Cover in Tenths	Contraction	Remarks
1/10 to less than 10/10 surface-based obscuring phenomena	-X	No height assigned this condition. Vertic visibility is not completely restricted.
10/10 surface-based obscuring phenomena	X	Always preceded by a vertical visibility
Less than 1/10	CLR	This contraction is not used in combinati with others. If considered significant, i a remark in column 13 pertaining to the p of less than 1/10 clouds, e.g., STFRA NW.
1/10 thru 5/10 half or more thin 1/10 thru 5/10 more than half opaque 6/10 thru 9/10 half or more thin	-SCT SCT -BKN	Height values preceding these contraction never designated as ceiling layers.
6/10 thru 9/10 more than half opaque	BKN	Height value preceding this contraction p with a ceiling layer designator provided ceiling layer is not present.
10/10 half or more thin	-OVC	Height value preceding this contraction i prefixed with a ceiling layer designator.
10/10 more than half opaque	OVC	This contraction is used in combination w lower overcast layers only when such laye classified as thin. Height value precedin contraction is prefixed with a ceiling la designator provided a lower broken ceilin is not present.

Table 5-2.—Sky cover contractions

ation Amount of Cover in Tenths	Contraction	Remarks
to less than surface-based uring phenomena	-X	No height assigned this condition. Vertical visibility is not completely restricted.
surface-based uring phenomena	X	Always preceded by a vertical visibility value.
than 1/10	CLR	This contraction is not used in combination with others. If considered significant, include a remark in column 13 pertaining to the presence of less than 1/10 clouds, e.g., STFRA NW.
thru 5/10 half re thin thru 5/10 more half opaque thru 9/10 half re thin	-SCT SCT -BKN	Height values preceding these contractions are never designated as ceiling layers.
thru 9/10 more half opaque	BKN	Height value preceding this contraction prefixed with a ceiling layer designator provided a lower ceiling layer is not present.
half or more	-OVC	Height value preceding this contraction is never prefixed with a ceiling layer designator.
more than opaque	OVC	This contraction is used in combination with lower overcast layers only when such layers are classified as thin. Height value preceding this contraction is prefixed with a ceiling layer designator provided a lower broken ceiling layer is not present.

the forward and rear edges and the tenths of sky corresponding to each elevation. The difference equals the sky cover. For example: forward edge 78° = 0.4 sky cover; rear edge 53° = 0.2 sky cover. Total sky cover is the difference between the two, or 0.2 sky cover.

When a continuous layer surrounds the station and extends to the horizon, determine the angular elevation of the edge, and convert to tenths of sky cover. (See table 5-1.) Since such a distribution is improbable, the table serves only as a guide in estimating amounts in situations that approach such a configuration.

At night, the use of a ceilometer or ceiling light aids the weather observer greatly in estimating the amount of sky cover of layers of clouds.

After the observer has determined the amount of sky cover and assigned a value to the various layers present, a classification for each layer can now be made in accordance with table 5-2.

Variable Sky Cover

"Variable sky condition" refers to a sky condition which has varied between reportable conditions (e.g., SCT to BKN, etc.) during the period of observation (normally the past 15 minutes).

When a ceiling is variable and is less than 3000 feet, it must be reported. Ceilings above 3000 feet that are variable may be reported if considered operationally significant by the observer. The average of all observed values is used as the ceiling.

Determining Cloud Heights

There are many methods that may be used to determine the heights of cloud bases. These include the use of balloons; radar height data; known heights of landmarks; convective cloud height diagrams; pilot reports; and ceiling lights and ceilometers. (Refer to FMH No. 1 for guidance in selecting the most reliable method.) If the above methods cannot be used, the Aerographer's Mate can estimate the heights relying on his experience and knowledge of cloud forms, and from a comparison with previous observations.

Landmarks, including mountains, trees, buildings, etc., may be used as reference where the heights of the objects above the surrounding terrain and observation point are known. Normally, each weather unit maintains a chart (or a list) showing objects suitable for reference heights.

Aircraft Determinations (PIREPS)

Many pilot reports (PIREPS) of sky conditions are received daily from aircraft. Prior to incorporating these reports into an aviation hourly weather report, the observer should be sure that certain rules are met and understood. These rules are as follows:

1. All heights are reported from aircraft in hundreds of feet above MSL (mean sea level), and a correction is applied to the height to report the bases of cloud layers AGL (above ground level) over your station.
2. Heights of low and middle clouds are reported within 1 1/2 nautical miles of a runway of the airport and within 15 minutes of the actual time of observation.
3. Heights of cirriform clouds are reported within 50 nautical miles of a runway of the airport and during the past hour preceding the observation.

Regardless of the method used, heights of layers are determined and reported in terms of feet above the surface of the station and are rounded to the reportable values in accordance with table 5-3.

NOTE: For cloud heights that are halfway between reportable values use the smaller of the two values.

Table 5-3.—Sky cover height values

Feet	Reportable values (coded in hundreds of feet)	Entries
5,000 or less.	To nearest 100 ft.	1, 10, 50, etc.
5,001 to 10,000.	To nearest 500 ft.	55, 75, 100, etc.
Above 10,000.	To nearest 1,000 ft.	140, 180, 200, etc.

After determining the height of all of the cloud layers, the observer can now assign a ceiling designator to the ceiling, if one is present. Table 5-4 lists the various ceiling designators. However, for complete information on ceiling designators, refer to FMH No. 1.

Visibility

Visibility observations are taken from as many points as necessary to view as much of the horizon as practicable.

Observing Aids

Visibility charts, lists of visibility markers, or other positive means of identifying a representative sample of lights or objects used in determining visibility at the station are maintained near the observing position. These include lights and objects for both day and night use; at local discretion, separate lists or charts for daytime or nighttime use may be maintained. See figure 5-2 for a typical daytime visibility marker chart maintained at a weather station. Panoramic photographs may be used to supplement visibility charts. Distances and cardinal compass points are entered on such photographs. Where control tower visibility is observed, separate charts or lists using the control tower as the point of observation are normally needed.

Refer to FMH No. 1 for complete instructions for construction of visibility marker charts or lists and for the selection of daytime and nighttime markers.

Determining Visibility

Using all available visibility markers, determine the greatest distance that you can see in all directions around the horizon circle. When the visibility is greater than the distance to the farthest markers, estimate the greatest distance you can see in each direction. Base this estimation on the appearance of your markers. If they are visible with sharp outlines and little blurring of color, the visibility is much greater than the distance of the markers. However, if they can barely be seen and identified, the visibility is about the same as the distance to the markers. Prior to taking a visibility observation at night, spend as much time as practicable in the darkness to allow the eyes to be accustomed to the limited light.

Reportable Values

Visibility is reported at land stations in statute miles, and at ocean stations in nautical miles, using the values given in table 5-5. If the visibility is halfway between two reportable values, select the lower.

Prevailing Visibility

Prevailing visibility is the greatest visibility which is attained or surpassed throughout at least half of the horizon circle not necessarily continuous. This term is synonymous with the term "horizontal visibility" as used in the synoptic code. If the visibility is variable (i.e., the prevailing visibility rapidly increases and decreases by one or more reportable values during the period of the observation), the average of all observed values is the prevailing visibility.

In uniform conditions the determination is relatively simple because the prevailing visibility will be the same as the visibility in any direction.

In nonuniform conditions one aid for determining prevailing visibility is to divide the horizon circle into several sectors, each of which has substantially uniform visibility. The observer then must determine the visibility value that equals or surpasses at least one-half of the horizon circle. (See fig. 5-3 for various examples.)

Sector Visibility

Sector visibility is the visibility within a specified sector of the horizon circle having essentially uniform visibility. As in the case of prevailing visibility, it represents the greatest horizontal distance that an observer can see and identify dark objects against the horizon sky in the daytime, or see and identify moderate intensity, unfocused lights at night.

Transmissometer data (discussed later in the chapter) may also be used as an aid in

Table 5-4.–Ceiling designators and applicable methods of determining them

(M) Measured ceiling

1. Ceiling light or ceilometer light values of less than 10 times the baseline, to the nearest reportable value.
2. Based on known heights of unobscured portions of abrupt, isolated objects (normally, other than natural landmarks) within 1½ nautical miles of a runway of the airport.
3. Radar ceilings determined with "Cloud Detection Radar" equipment considered by the operator to be reliable and, in the judgment of the observer, considered to be possible and probable on the basis of visual observation.

(E) Estimated ceiling

1. Pilot reports of heights of:
   a. Layers of obscuring phenomena aloft, or cloud other than cirriform, observed within 15 minutes of actual time of observation and 1½ nautical miles of a runway of the airport. These layers need not be reported if, in the judgment of the observer, they are not representative of conditions over the airport.
   b. Cirriform layers observed within 50 nautical miles of the airport, within 1 hour of time of the entry on MF1-10.
2. Balloon (ceiling or pilot), based on known ascension rates and time of ascent until observed to enter the base of the layer. See Tables in FMH-1. Should also be used if the ceiling cannot be determined by ceiling light, ceilometer, radar, or pilot report.
3. Determined by means of the convective cloud height diagram.
4. Determined from known heights of unobscured portions of natural landmarks or objects more than 1½ nautical miles from any runway of the airport.
5. Determined on the basis of observational experience; provided the sky is not completely hidden by surface-based obscuring phenomena; and other guides are lacking or, in the judgment of the observer, are considered to be unreliable.
6. Determined by ceilometer or ceiling light and the penetration of the light beam is in excess of normal for the particular height and type of layer present.
7. Determined by ceilometer or ceiling light and the values equal or exceed 10 times the baseline used.
8. Determined from weather-surveillance radar range height indicator (RHI) scope displays.
9. Determined from cloud detection radars when the heights are not considered sufficiently reliable to warrant use of a "M" height classification.

warrant use of a "
classification.

(W) Indefinite c
(Surface based pheno

1. The distance that
server at the grou
see upward to an o
phenomena complete
scuring the sky.
2. Based on the visib
tions of nearby ob
(buildings, contro
etc.) on the airpo
plex.
3. Based on a height
to a ceilometer up
reaction, the top
ceiling light beam
height at which a
completely disappe
4. Based on the maxim
tical height above
within 1½ nautical
runway of the airp
within 15 minutes
actual time of an
from which a pilot
surface-based obsc
(obscured sky cond
can discern the gr
These pilot-report
values may be disr
if in the judgment
observer they are
resentative of con
over the airport.

Table 5-4.—Ceiling designators and applicable methods of determining them

ured ceiling or ceilometer light s than 10 times the the nearest report- n heights of unob- ns of abrupt, iso- (normally, other landmarks) within iles of a runway of s determined with ion Radar" equipment the operator to be in the judgment of considered to be probable on the basis ervation.	2. Balloon (ceiling or pilot), based on known ascension rates and time of ascent until observed to enter the base of the layer. See Tables in FMH-1. Should also be used if the ceiling cannot be determined by ceiling light, ceilometer, radar, or pilot report. 3. Determined by means of the convective cloud height diagram. 4. Determined from known heights of unobscured portions of natural landmarks or objects more than 1½ nautical miles from any runway of the airport. 5. Determined on the basis of observational experience; provided the sky is not completely hidden by surface-based obscuring phenomena; and other guides are lacking or, in the judgment of the observer, are considered to be unreliable. 6. Determined by ceilometer or ceiling light and the penetration of the light beam is in excess of normal for the particular height and type of layer present. 7. Determined by ceilometer or ceiling light and the values equal or exceed 10 times the baseline used. 8. Determined from weather-surveillance radar range height indicator (RHI) scope displays. 9. Determined from cloud detection radars when the heights are not considered sufficiently reliable to warrant use of a "M" height classification.	warrant use of a "M" height classification.
mated ceiling of heights of: obscuring phenomena cloud other than observed within 15 actual time of n and 1½ nautical runway of the air- e layers need not be f, in the judgment of er, they are not tive of conditions irport. layers observed with- ical miles of the ithin 1 hour of time ry on MF1-10.		(W) Indefinite ceiling (Surface based phenomena only) 1. The distance that an observer at the ground can see upward to an obscuring phenomena completely obscuring the sky. 2. Based on the visible portions of nearby objects (buildings, control towers, etc.) on the airport complex. 3. Based on a height equivalent to a ceilometer upper limit reaction, the top of a ceiling light beam, or the height at which a balloon completely disappears. 4. Based on the maximum vertical height above the ground within 1½ nautical miles of a runway of the airport and within 15 minutes of the actual time of an observation from which a pilot in a surface-based obscuration (obscured sky condition) can discern the ground. These pilot-reported values may be disregarded, if in the judgment of the observer they are not representative of conditions over the airport.

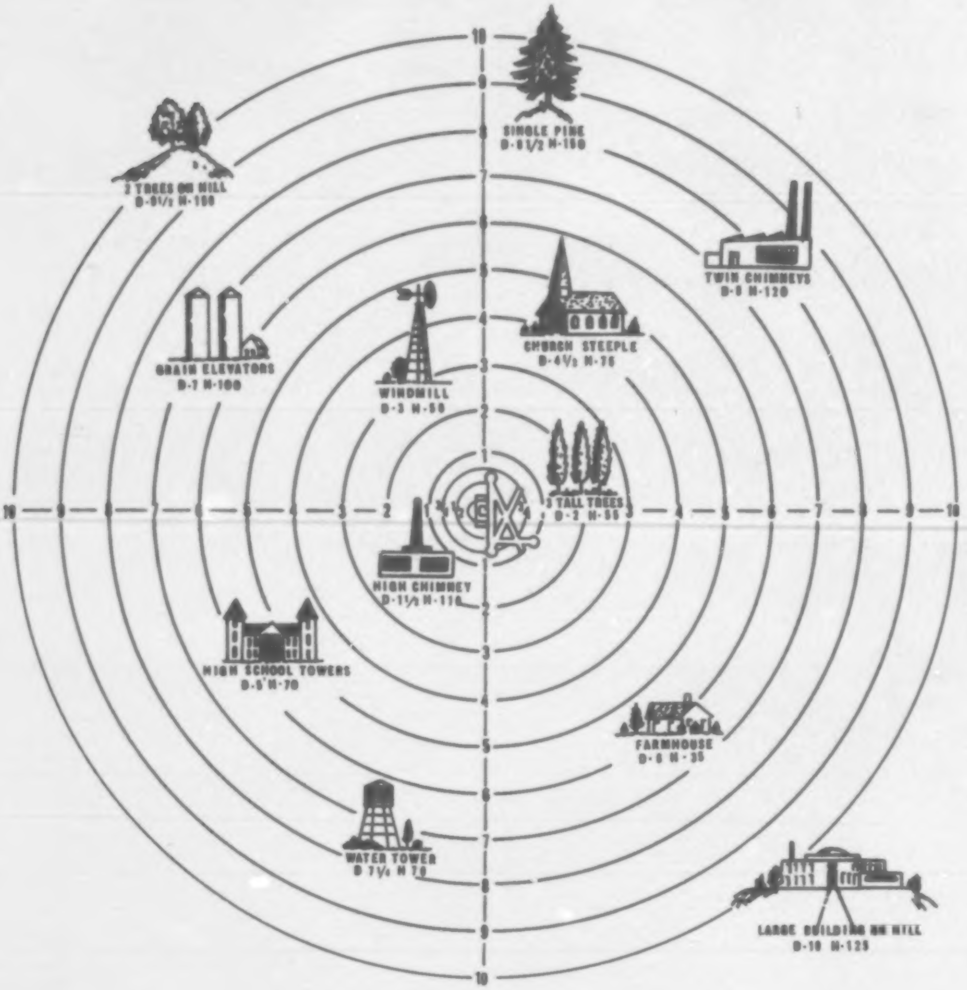

SINGLE PINE
D-9½ H-150
2 TREES ON HILL
D-9½ H-100
TWIN CHIMNEYS
D-8 H-120
GRAIN ELEVATORS
D-7 H-100
WINDMILL
D-3 H-50
CHURCH STEEPLE
D-4½ H-75
3 TALL TREES
D-2 H-55
HIGH CHIMNEY
D-1½ H-110
HIGH SCHOOL TOWERS
D-5 H-70
FARMHOUSE
D-6 H-35
WATER TOWER
D 7½ H 70
LARGE BUILDING ON HILL
D-10 H-125
10
9
8
7
6
5
4
3
2
1
½

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Figure 5-2.—Sample daytime visibility marker chart. (D = distance to object, H = height of object in feet.)

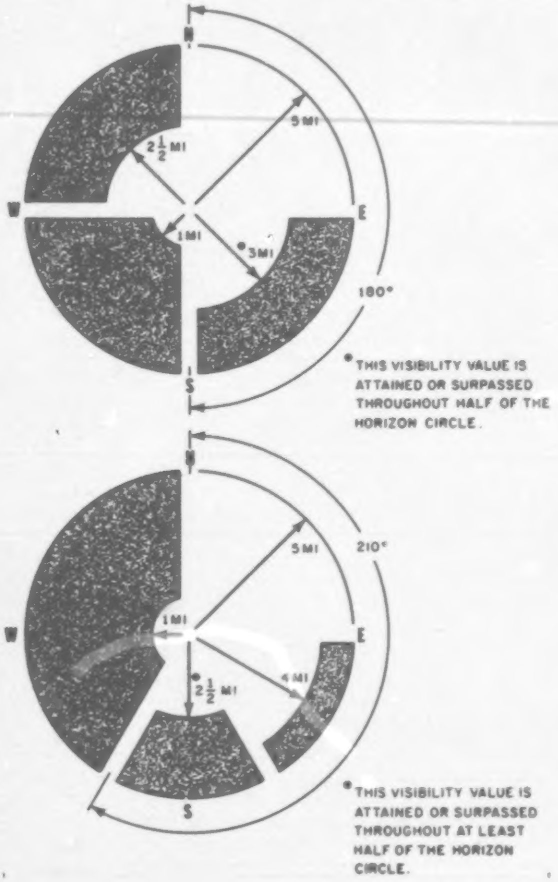
determining the visibility in the sector in which the instrument is installed provided the observer determines that the visibility is uniform throughout that sector. This use is dependent upon the transmissometer value being less than 2 miles. During other visibility conditions and in other sectors, determine the sector visibility by visual observations when necessary.

Variable Visibility

Variable visibility refers to a condition in which the visibility varies by one or more reportable values during the period of observation. The average of all observed values is used as the visibility. The limits of variability must be reported when the average is less than 3 miles.

Table 5-5. —Reportable visibility values (Miles)

Increments of Separation (Miles)							
1/16	1/8		1/4	1/2	1		5
0	3/8	1 1/4	2	2 1/2	3	10	15
1/16	1/2	1 3/8	2 1/4	3	4	11	20
1/8	5/8	1 1/2	2 1/2		5	12	25
3/16	3/4	1 5/8			6	13	30
1/4	7/8	1 3/4			7	14	35
5/16	1	1 7/8			8	15	40
3/8	1 1/8	2			9		etc.



*THIS VISIBILITY VALUE IS ATTAINED OR SURPASSED THROUGHOUT HALF OF THE HORIZON CIRCLE.

*THIS VISIBILITY VALUE IS ATTAINED OR SURPASSED THROUGHOUT AT LEAST HALF OF THE HORIZON CIRCLE.

209.215

Figure 5-3. —Illustrative examples of determining prevailing visibility.

Control Tower Visibility

Unless otherwise exempted, certified tower personnel will report prevailing visibility when the prevailing visibility at the usual point of observation or at the tower level is less than 4 miles. These observations may be used immediately for aircraft operations. As soon as practicable they should be recorded on a graphic transcriber, MF1-10, or separate form with the time of observation, prevailing visibility, remarks, and the observer's initials. It should then be forwarded to the weather office.

Weather office personnel should also advise the tower as soon as possible when the surface visibility decreases to less than, or increases to equal or exceed 4 miles. Weather office personnel should also re-evaluate weather station prevailing visibility, as soon as practicable, upon receipt of a differing tower value, and upon receipt of subsequent reportable changes in tower visibility. They shall also use tower values at stations where the observer's view of portions of the horizon is obstructed by trees, buildings, etc. If a surface-based obstruction to vision that is uniformly distributed to heights above the tower exists, it will constitute a sufficient reason to classify the weather station's prevailing visibility to be the same as the towers.

Runway Visibility (RVV)

Runway visibility is the visibility along an identified runway. Where a transmissometer is used for measurement, the instrument is calibrated to indicate values statistically comparable to those that would be observed by a human observer, using as targets either dark objects against the horizon sky during daylight or moderately intense unfocused lights at night; and are applicable only to the specified runway or runways near which the instrument is located. When the instrument is defective, or when the observer has reliable reports or has otherwise determined that the transmissometer indication is not a representative value for the runway, transmissometer data will not be used.

Report runway visibility when it is less than 2 miles along the identified runway, or the prevailing visibility is less than the highest instrument minimum for the identified runway.

Most transmissometer equipment used by Naval Weather Service units have visibility meters and recorders that are equipped with day and night scales. The weather observer has only then to read the correct scale, dependent upon the time of the day, to the nearest reportable visibility value.

Runway Visual Range (RVR)

In the United States, runway visual range is an instrumentally derived value from equipment located alongside and about 14 feet higher than the center line of the runway and clibrated with reference to the sighting of high-intensity runway lights or the visual contrast of other targets, whichever yields the greater value. This value represents the horizontal distance a pilot will see down the runway on takeoff or landing. Navy stations are not equipped to report this value.

FORMS

The same forms (MF1-10 and NWSC 3140/8) are used to record cloud and visibility data as mentioned previously, along with the recording rolls used in the Cloud Height Set GMQ-13 ( ) and Transmissometer Set GMQ-10 ( ).

MF1-10 Entries

The entries pertaining to ceiling, sky condition, and visibility are described in the following sections. Again, when in doubt, consult FMH-1 as your final authority.

SKY AND CEILING (COL. 3).—For each layer visible at the station at and below the lowest overcast layer not classified as thin, enter sky-cover data (in ascending order of the height of the bases of layers), the ceiling classification, if the layer is a ceiling layer (table 5-4); the height of the layer, in accordance with table 5-3 followed by the suffix "V" for variable ceilings, if applicable; and the sky cover contraction appropriate to the layer, (table 5-2) based on the amount of sky cover at and below the level reported (summation amount), and on the transparency of visible portions of the layer.

Height values are not given to surface-based layers classified as a partial obscuration "-X". The height ascribed to an obscuration "X" represents vertical visibility and is always preceded by the ceiling designator "W".

VISIBILITY (COL. 4).—Enter the prevailing visibility as determined from the weather station's usual visual point(s) of observation using the reportable values (table 5-5). When visibility is less than 3 miles and fluctuating rapidly between one or more reportable values, suffix the average with a "V" and enter the range of variability in the remarks section.

VISIBILITY (COL. 4a).—Enter the tower's prevailing visibility using table 5-5 whenever the reported prevailing visibility at the usual point of observation is less than 4 miles and the reported tower visibility is more than half the value entered in column 4, but less than 7 miles. Refer to FMH-1 for the proper procedures for entry into the transmitted report.

REMARKS (COL. 13).—There are many mandatory and optional remarks made in column 13 which relate to ceiling, sky condition, and visibility. These remarks serve the purpose of explaining certain column 3 and 4 entries, or data concerning sky condition and visibility criteria that cannot be entered in columns 3 and 4 for various reasons.

CEILING AND SKY CONDITION REMARKS.—These remarks should include base and top reports by pilots of layers not visible at the station. Other remarks would include breaks in the overcast (BINOVC), higher clouds visible through breaks in overcast (HIR CLDS VSB), towering cumulus (TCU) or other significant types (See table 5-6 for cloud-type contractions), obscuring phenomena at the surface and aloft (K5 for smoke at the surface hiding 5/10 of the sky, etc.), variable sky condition (SCT V BKN, etc.), variable ceiling (CIG 15V 20), or differing ceiling or sky condition at a distance from the station (CIG LWR OVR CITY, etc.). Remarks will be entered in accordance with the priority outlined in FMH-1 chapter A-3. For more detailed information, refer to that manual.

VISIBILITY REMARKS.—When these remarks are not otherwise identified, they relate to the same observation point as the visibility value used in the body of the coded aviation weather report. The most common type of entries are as follows:

1. VISIBILITY BY SECTORS: Enter sector visibility when it differs from the prevailing visibility and is less than 3 miles, or is considered operationally significant when equal to or more than 3 miles. Prefix each value with the corresponding sector designator (e.g., with prevailing visibility of 8 miles and sector visibilities of NE 4, SW 8, and NW 2, enter in remarks VSBY NE 4 NW2).

2. VARIABLE VISIBILITY: When prevailing visibility is variable and is less than 3 miles, enter the range of variability separated by "V"; e.g., "VSBY 1V2."

3. RUNWAY VISIBILITY: Runway visibility is entered in column 13 when the visibility is less than 2 miles along the appropriate runway, when prevailing visibility is less than the highest instrument minimum for the appropriate runway, or when runway visibility is considered operationally significant. Refer to FMH No. 1 for code format for column 13 entry.

TOTAL SKY COVER (COL. 21).—At each record (hourly) observation, enter as a whole number of tenths of the total sky covered by clouds and obscuring phenomena aloft, and sky hidden by surface-based obscurations which are visible at the station.

TOTAL OPAQUE SKY COVER (COL. 36).—Enter, as a whole number, the tenths of sky that are hidden by clouds or obscuring phenomena. This entry is similar to the entry for total sky cover in column 21, except that sky cover through which the sky is visible is disregarded when determining the entry for total opaque sky cover. Maximum entry is 10.

Table 5-6.—Cloud types and contractions

Cloud types	Contractions
Altocumulus	AC
Altocumulus castellanus	ACCAS
Altocumulus (lenticular)	ACSL
Altostratus	AS
Cirrocumulus	CC
Cirrocumulus (lenticular)	CCSL
Cirrostratus	CS
Cirrus	CI
Cumulonimbus	CB
Cumulonimbus mamma (Mammatocumulus)	CBMAM
Cumulus	CU
Cumulus Fractus	CUFRA
Tower Cumulus	TCU
Stratus Fractus	STFRA
Nimbostratus	NS
Stratocumulus	SC
Stratocumulus (lenticular)	SCSL
Stratus	ST

NWSC 3140/8 Entries

SKY AND CEILING (COL. 6).—Enter the ceiling and sky cover data in accordance with previous instructions listed for column 3 of MF1-10.

VISIBILITY (COL. 7).—Prevailing visibility is reported in nautical miles and is determined in the same manner as for surface observations, except that visibility markers, of course, cannot be utilized. In estimating visibility, use radar or stadiometer distance or other distances to known objects, such as ships in company, horizon, etc. For a table which shows the distance to objects on the horizon at sea level in nautical miles, see NAVWEASERVCOMINST 3144.1 Chapter IV.

SKY COVER DATA (COLS. 17 AND 18).—Enter sky cover data for columns 17 and 18 in the same manner as in the columns 21 and 36 respectively of MF1-10.

REMARKS (COL. 16).—Enter appropriate remarks in the same manner as in column 13 of MF1-10. The major exception to this is that 3- and 6-hourly additive data entered at land stations is not entered in marine aviation observations.

Recording Charts

The Cloud Height Set AN/GMQ-13 ( ) and Transmissometer AN/GMQ-10 ( ) recorder records require specific entries and adjustments to be applied to them during their operation.

The ceilometer (AN/GMQ-13 ( )) records should be handled in the following manner:

1. Enter station name, time check, and date-time (LST) group at beginning and end of chart or any detached portion of chart.

Enter time check and date-time group near the trace during periods of operation at the time of each 6-hourly observation, when notified of an aircraft accident at or in the vicinity of the station; and when the recorder is stopped or started.

Enter dual time checks, a date-time group, and an arrow from time check at end of trace to time check at beginning of trace, when chart is adjusted for time. Make time adjustments when error at time of inspection exceeds 2 1/2 minutes. Frequency of inspections should be such as to make it unlikely that time errors will reach 5 minutes.

2. Retain complete ceilometer records for 3 months after which they may be destroyed unless otherwise instructed.

Transmissometer (AN/GMQ-10 ( )) records should be handled in the following manner:

1. Place station name, time check, date-time group (LST), runway number and length of transmissometer baseline at the beginning and ending of each chart.

Enter a time check and date-time group (LST) at the actual time of each 6-hourly observation.

Indicate maintenance shutdowns or other periods of nonoperation by inscribing time checks and date-time groups at the end of one period of operation and beginning of the next.

Enter a time check and date-time group near the trace whenever notified of an aircraft mishap at or in the vicinity of the station.

Adjust the chart to correct time whenever the time error is 5 minutes or more and note the time of adjustment and a new time check on the recorder chart.

2. When the transmissometer recorder roll has been exhausted, it should be placed in the empty chart carton. The station name, dates for beginning and ending of roll and runway identification should be entered on the carton, and the used roll retained as prescribed by local instructions.

CLOUD HEIGHT MEASURING EQUIPMENT

The accurate determination of cloud heights is a difficult problem to solve under all conditions. To aid in obtaining these determinations, several types of equipment have been devised. Some are capable of night determination only, while others provide capability for both day and night observations. The following paragraphs will describe these equipments, their operation, and maintenance.

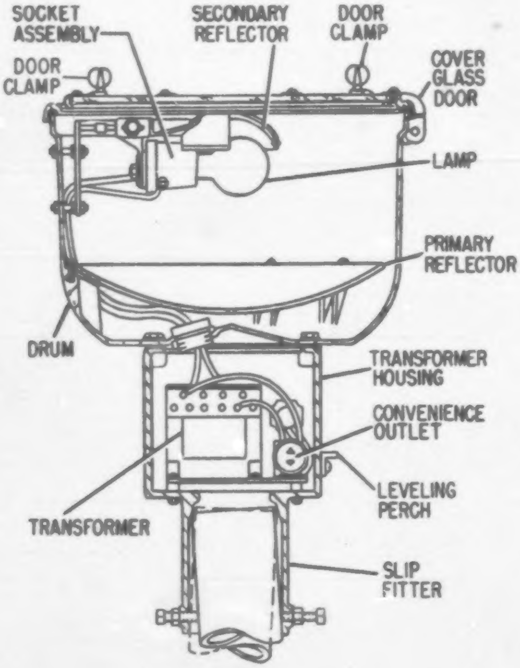
CEILING LIGHT PROJECTOR ML-121

The Ceiling Light Projector ML-121 (fig. 5-4) consists of a drum and an optical system. The drum is a weatherproof one-piece casting which holds the various parts of the projector in their correct positions. Leveling perches, 90° apart, are adjusted so that the beam is directed at the zenith when both perches are level.

The optical system consists of the lamp, primary reflector, secondary reflector, socket assembly, supporting base, and transformer.

The primary reflector is a parabolic mirror constructed of silvered, high-transmission glass, while the secondary reflector is a spherical, silvered glass mirror, both of which do not crack when subjected to repeated heating and cooling cycles.

The secondary reflector is held in a spherical reflector holder which is rigidly mounted on an arm of the socket assembly so that the focal points of the reflector and lamp coincide.



209.110
Figure 5-4.—Ceiling light projector ML-121 detail.

The socket assembly consists of a cast aluminum or iron base and is located so that it supports the lamp at the focal point of the secondary reflector.

The base of the projector is a single casting for both the transformer housing and slip fitter. The slip fitter is designed to fit over a 4-inch standard pipe with sufficient play to permit leveling of the drum by four setscrews.

Operation

The ceiling light projector should be installed so that a standard baseline (horizontal distance from projector to observation point) near 800 feet can be established and so that supplementary baselines near 400 and 1,600 feet can be marked when practicable. The 400-foot baseline is for use when clouds are below 500 feet; the 1,600-foot baseline is for use when clouds are above 10,000 feet.

It is not necessary for the observation point and the projector to be at the same level when the clinometer is used. The control switch should be convenient to the observation point, so that the light need not be turned on for a period of time longer than required to obtain an observation. Since the ceiling light projector is generally close to the field, never leave it on any longer than necessary, as the powerful light may blind night-flying pilots during a field approach. When at all practicable, the line of sight should be from south to north in order to avoid the occasional inconvenience due to moonlight on thin cloud patches. The projector must be carefully leveled, and the level must be checked frequently to ensure a true vertical light beam. The lamp should be focused so as to throw a narrow, concentrated shaft of light.

Maintenance

In order to ensure full beam intensity, clean the cover glass on the projector housing and the reflector's surfaces once a week or oftener as necessary. Liquid glass cleaners or other nonabrasive glass cleaners, used with soft clean cloths, are recommended for this maintenance.

Inspect the drainage holes in the mirror and housing, and clean them as often as is necessary to ensure adequate drainage and ventilation of the enclosure.

Replace defective lamps promptly whenever the lamp has begun to blacken or the filament sags to a noticeable extent. Lamp life varies considerably due to local conditions and is highly critical with respect to overvoltage or excess voltage fluctuations. If short lamp life or a reduction in lamp intensity is noted, notify your supervisor.

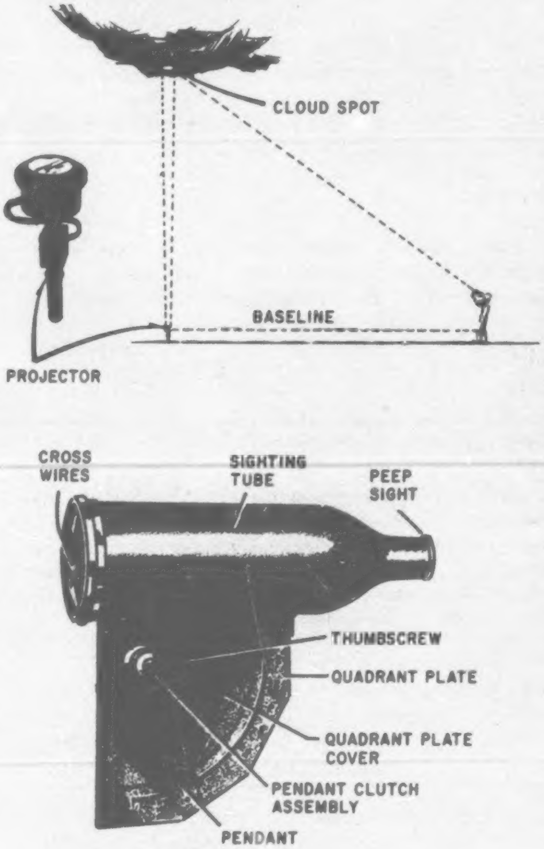
The lamp and the reflector are properly focused by the manufacturer and ordinarily should not need adjustment. When the focus goes out of adjustment, notify your supervisor.

The light beam should be checked frequently for verticality. It may be checked with a theodolite and a spirit level. Use the spirit level to check on the levelness of the projector. If the projector is level but the beam is not vertical, the trouble is in the focusing assembly, and the beam needs vertical alignment. Notify your supervisor when the light beam is not vertical.

CAUTION: Always wear dark glasses when working near the light beam. Also, never attempt to work on the projector with the power on.

CLINOMETER ML-119 (SHORE TYPE)

The Clinometer ML-119 is the portable hand instrument used to measure the angular elevation of a projected light "spot" on the base of a cloud. The clinometer consists of a sighting tube nearly 3 inches in diameter at its outer end. This size is necessary in order that not only the light spot on the cloud, but a portion of the surrounding dark sky as well, may be included for contrast in the field of view. A pair of cross wires aids the eye in centering on the light spot. A quadrant with a scale from 0° to 90°, in whole degrees graduations, is rigidly attached to the underside of the tube, and a weighted pendant is pivoted so as to hang vertically of its own weight when the tube is sighted on an object. The reference line on the pendant coincides with the 90° line on the quadrant when it is sighted on the zenith. A clutch, operated with the left hand by means of a milled-head thumbscrew, clamps the pendant in position when a sight is made. (Refer to fig. 5-5.)



CLINOMETER

209.111

Figure 5-5.—Ceiling light projector and clinometer ML-119.

To determine the cloud height, loosen the pointer thumbscrew. Sight the clinometer with the cross wires centered upon the lower part of the most clearly defined light spot on the cloud; tighten the clutch by means of the thumbscrew. Read the elevation angle to the nearest whole degree from the quadrant. The average elevation angle obtained by three sightings should be used to obtain the cloud height. Simple triangulation then enables the cloud height to be computed by using the known horizontal distance from the observer to the projector as a baseline. The height in feet equals the distance (length of the baseline in feet) multiplied by the natural tangent of the elevation angle. The height so determined is the height of the cloud above the observer. This height must then be corrected by an amount equal to the difference in elevation of the point of observation and the field elevation or ground. For convenience, a table of heights plotted against observed elevation angles should be made up for use of the observer.

Maintenance

When the clinometer is not in use, keep it in its case to protect the instrument from dust and dirt. Keep the pendant clamped to prevent it from being damaged by sudden movements or jolts. The clinometer is dusted, when necessary, with a clean soft cloth.

Check the clinometer monthly for accuracy in the following manner:

With the sighting tube in a horizontal position, rest the front edge of the quadrant scale plate on a level surface. The pendant should indicate 0°. If the instrument does not register accurately, return it for repair in accordance with current instructions.

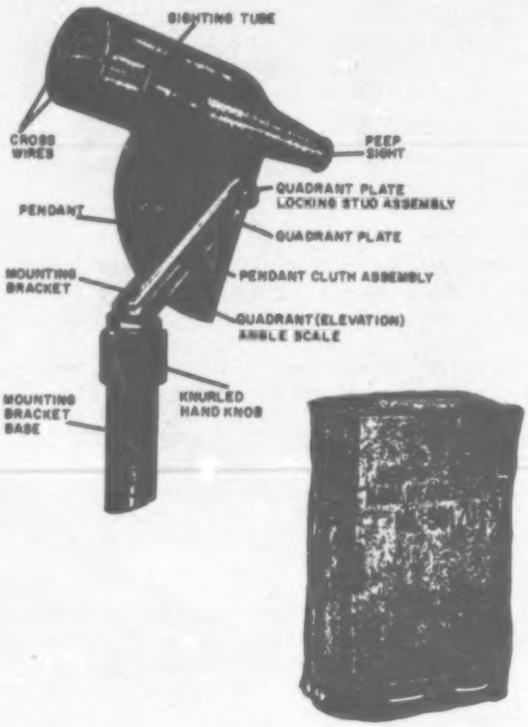
CLINOMETER ML-591/U (SHIPBOARD TYPE)

This clinometer is designed for shipboard use only. It is used for measuring the elevation angle of a spot of light thrown on the base of a cloud by a ceiling light projector or searchlight in the same manner as the ML-119 previously mentioned, with minor exceptions. This instrument will usually be permanently mounted and will require periodic orientation.

Description

Clinometer ML-591/U is composed of a sighting tube attached to a quadrant plate, an angle scale, a pendant, a pendant lock stud assembly, a pendant clutch assembly, a mounting bracket, and a mounting bracket base. (See fig. 5-6.)

The entire surface of the sighting tube and quadrant plate is dull black anodized. The sighting tube is bottle-shaped with a 1/4-inch diameter peep sight in the small end and cross wires in the large (3-inch diameter) end. The angle scale and pendant are engraved, dull black anodized and white filled. The quadrant plate and pendant are attached to the mounting bracket with the pendant lock stud assembly. The pendant is secured in the desired position with the pendant clutch assembly. The mounting bracket fits into the mounting bracket base and is held at the desired height and heading with a phenolic resin laminated insert in the knurled hand knob. The mounting bracket base is secured to the ship by a pipe welded to the deck. The location of the clinometer should be out of the glare of lights when making a sight. When not in use, the clinometer is covered with a coated nylon bag (fig. 5-6) which is drawn tight around the bottom with a nylon drawstring.



209.112

Figure 5-6. — Clinometer ML-591/U (shipboard type) with cover.

Orientation

With the clinometer ML-591/U mounted on the support described above and tightened handtight, in a vertical fixed position (plus or minus 2 degrees), 4 feet above the deck, it should be oriented in the following manner: Loosen the knurled hand knob, raise the clinometer to eye level, aim the sighting tube at the center of the light beam, and tighten the hand knob (fig. 5-6). Loosen the pendant lock stud assembly and the pendant clutch assembly. Adjust the pendant index to zero while the line of sight is parallel with the deck.

This may be accomplished by placing a spirit level at a level point on the deck and a spirit level on the top of the sighting tube and adjusting the index to zero when the bubbles of both levels read the same inclination.

An alternate procedure is to adjust the index to zero while sighting at a spot on the ship which is the same height above the deck plane as the center of the sighting tube.

When the clinometer has been accurately leveled, establish a permanent orientation check mark on the ship. Read and record the angle with respect to the orientation check mark and the height of the mounting bracket above the knurled hand knob.

For subsequent orientation checks, sight on the orientation check mark and adjust the pendant index to the recorded angle when the mounting bracket is the correct height above the knurled hand knob.

Operation

Operation of Clinometer ML-591/U is performed as follows:

1. Remove coated nylon cover from clinometer.
2. Perform the orientation check as described above.
3. Loosen the knurled hand knob, and raise the clinometer to eye level.
4. Adjust the sighting tube so that the cross wires are centered on the beam of light (fig. 5-7) and tighten the knurled hand knob.
5. Release tension on pendant lock stud assembly.
6. Sight clinometer on center of the illuminated spot on the cloud base.
7. Secure pendant lock stud assembly.
8. Record elevation angle reading to closest 1/2 degree.
9. Repeat steps 5 through 8 three times.
10. Compute average of three readings.
11. Use tables to obtain measured cloud base height. (See fig. 5-7.) The actual cloud base height will be the measured height plus the height of the clinometer above sea level.
12. When the clinometer is not in use, replace the coated nylon cover and secure the drawstring.
13. If the clinometer will not be required for an extended period of time, remove it from the pipe support and store inside.

Maintenance

Check the accuracy and performance of the clinometer periodically on a 30-day cycle. Accomplish the clinometer performance test as follows:

1. Remove coated nylon cover.
2. Loosen knurled hand knob on mounting bracket base. Mounting bracket should slide freely within mounting bracket base.
3. With mounting bracket in extended position, secure knurled hand knob handtight. Clinometer must be capable of supporting at least 25 pounds.
4. Loosen pendant lock stud assembly. No more than one-quarter turn of stud must be required to free or secure sighting tube and quadrant plate assembly. Quadrant plate must swivel easily without binding or scraping. Swiveling quadrant plate must not cause lock stud assembly to turn.
5. Secure pendant lock stud assembly handtight. Sighting tube and quadrant plate assembly must be immobile.
6. Loosen pendant clutch assembly. Pendant must swivel freely.
7. Secure pendant clutch assembly fingertight. Pendant must be held immobile.
8. Return clinometer to correct height and heading and replace cover.
9. Check cross wires to determine if they have been damaged or bent out of alignment. Check alignment with a straightedge.

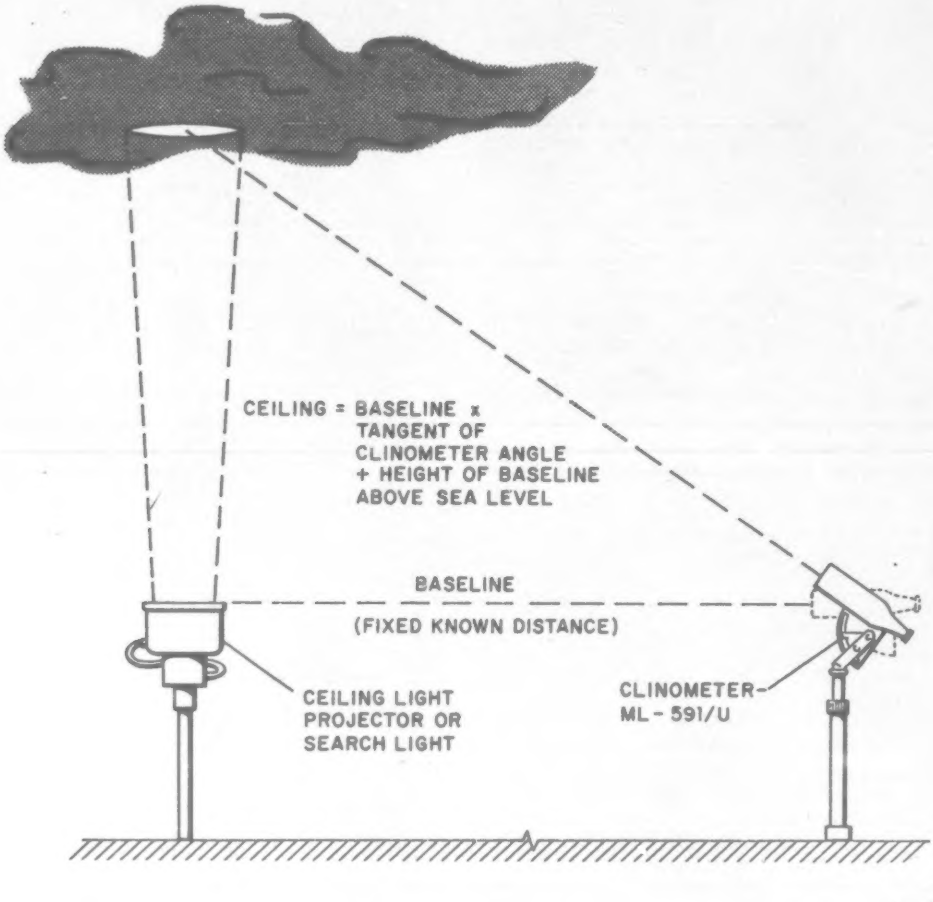

CEILING = BASELINE x
TANGENT OF
CLINOMETER ANGLE
+ HEIGHT OF BASELINE
ABOVE SEA LEVEL
BASELINE
(FIXED KNOWN DISTANCE)
CEILING LIGHT
PROJECTOR OR
SEARCH LIGHT
CLINOMETER-
ML - 591/U
209.113

Figure 5-7.—Obtaining cloud base height with Clinometer ML-591/U.

Check the clinometer for damage, wear, and corrosion. Maintenance is limited to cleaning, minor repair, replacement of damaged or worn parts, and adjustment. Instructions for major repairs and for disassembly are covered in the technical manual pertaining to this equipment.

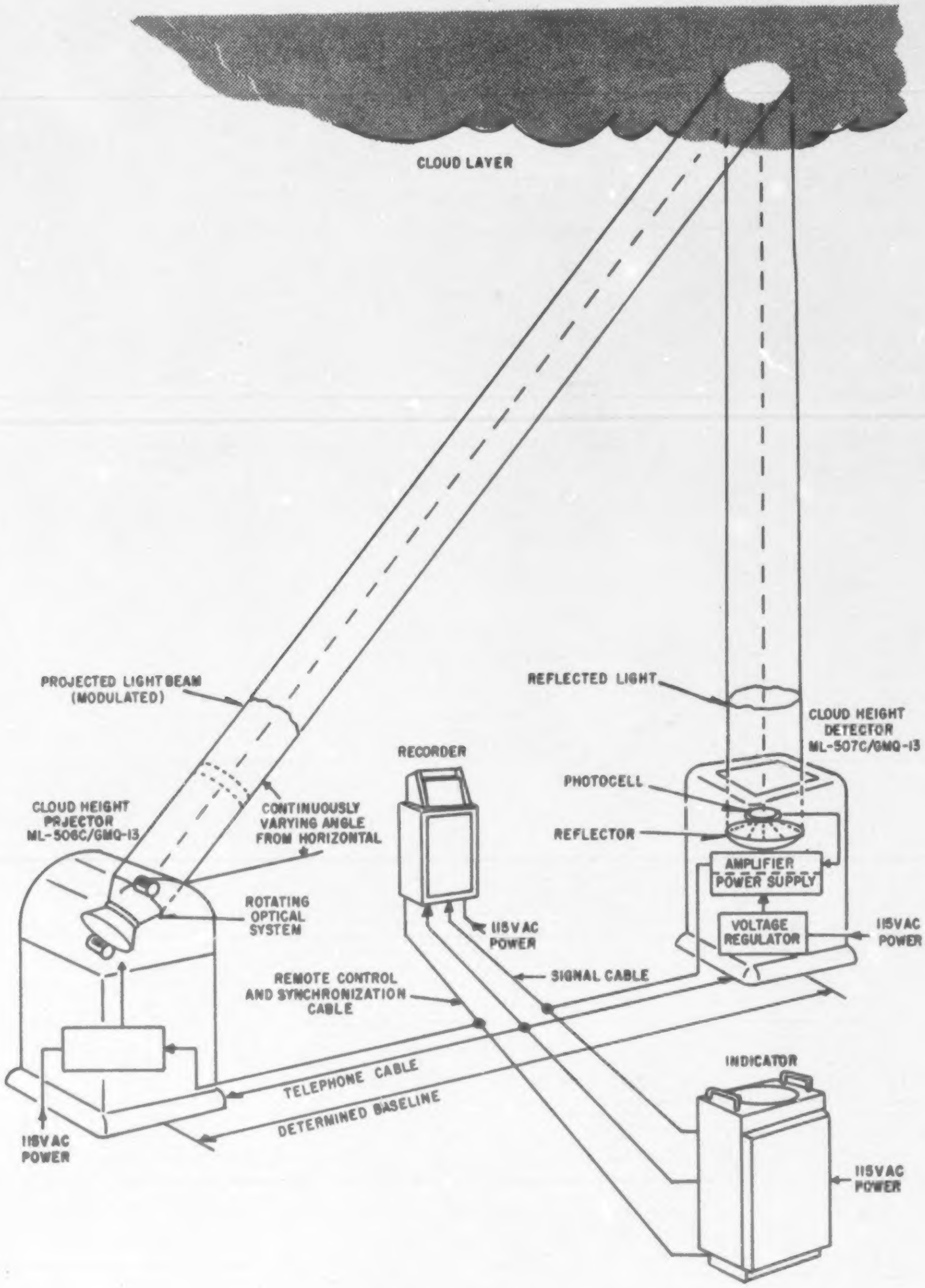
CLOUD HEIGHT SET AN/GMQ-13( )

The cloud height set is used on relatively short baselines of 400 to 900 feet, with the result that the highest accurate value of cloud height measurement is approximately 5,000 feet. The standard baseline is 400 feet. Cloud heights can be quite accurately measured in the height range of interest to pilots during final approach.

The cloud height set system was designed to give frequent measurements from a remote location. It is used primarily at the end of an instrument runway.

Operational efficiency of the equipment is influenced by several factors, such as possible interference by radio transmitters, vibration from various sources, strong induction fields, or proximity of high-intensity lamps having a high percent of modulation.

From an observational standpoint it is desirable to install the equipment in the approach zone of the most commonly used instrument runway near the middle marker.


CLOUD LAYER
PROJECTED LIGHT BEAM (MODULATED)
REFLECTED LIGHT
CLOUD HEIGHT DETECTOR ML-507C/GMQ-13
RECORDER
PHOTOCELL
CLOUD HEIGHT PROJECTOR ML-506C/GMQ-13
CONTINUOUSLY VARYING ANGLE FROM HORIZONTAL
REFLECTOR
AMPLIFIER
POWER SUPPLY
ROTATING OPTICAL SYSTEM
115VAC POWER
VOLTAGE REGULATOR
115VAC POWER
REMOTE CONTROL AND SYNCHRONIZATION CABLE
SIGNAL CABLE
INDICATOR
TELEPHONE CABLE
DETERMINED BASELINE
115VAC POWER
115VAC POWER

209.132

Figure 5-8.—Typical installation of Cloud Height Set AN/GMQ-13 ( ).

Components

Cloud Height Set AN/GMQ-13( ), or the rotating beam ceilometer, is composed of a detector, a projector, a recorder, and in some instances, an indicator. It is powered by 115-volt, 60-hertz alternating current. Figure 5-8 is a diagram of a typical installation and shows that the basic principle involved in making a cloud height measurement with a cloud height set is one of triangulation.

The DETECTOR is located at a known fixed distance (usually 400 feet) away from the projector, and the field of view of the detector is directed vertically upward. As the beam of the projector sweeps the cloud base, the light reflected from the cloud base in the detector field of view is received by the detector optical system (a parabolic reflector and photoelectric cell) and amplified by the detector amplifier. The output of the detector amplifier is fed by means of connecting cables or radio link to the recorder and/or indicator.

The PROJECTOR comprises two identical optical systems mounted back-to-back on a rotary mount such that modulated light beams which they project are continuously rotated in the plane of the detector's field of view. At some point in the rotation, each portion of the detector field of view from the top of the detector to the zenith is illuminated. Any cloud or other reflective obstruction will cause a light spot to occur as the light beams pass. The detector photocell and amplifier produce a signal voltage corresponding to the intensity of the spot on the clouds. Two light beams are used to increase the rate of measurement and to provide a safety factor in case of failure of one optical system.

The rotary mount which carries the two back-to-back optical systems rotates at the rate of 5 rpm. This means that the rotary mount makes a complete revolution in 12 seconds, and that the optical system projects a beam every 6 seconds. However, since each optical system is blocked off for one-half of the revolution through the upper semicircle, the actual sweep of each optical system is 3 seconds in duration. Each measuring sweep, therefore, lasts 3 seconds, and a measuring sweep is provided every 6 seconds.

The INDICATOR consists of a long persistence cathode-ray tube (CRT) with the appropriate electronic and mechanical circuits, and is housed in the weather office. The electron beam of the CRT moves up the vertical axis of the tube in synchronism with the rotation of the projector. When an amplified cloud signal from the detector is fed to the indicator (cathode-ray tube), it causes the electron beam to widen momentarily as the beam moves up the face of the CRT. The point at which the electron beam widens corresponds to the angle of the projector at which the light beam strikes the cloud over the detector. The face of the indicator CRT is calibrated in degrees

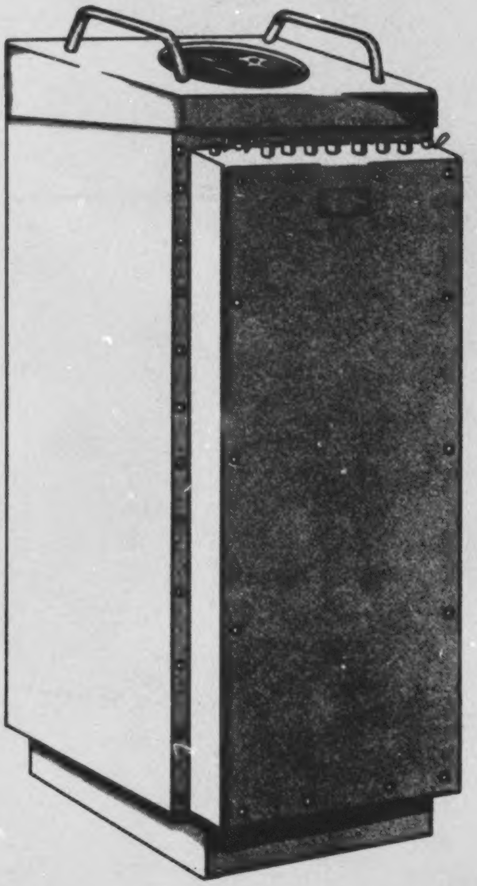

209.382

Figure 5-9.—Cloud height indicator IP-327B/GMQ-13.

(corresponding to the angle of projector rotation). This angular measurement can readily be converted into height by reference to precomputed tables. (See figs. 5-9 and 5-10.)

A RECORDER (RO-121/GMQ-13) which has been developed for use with this equipment is of the facsimile type. (See figs. 5-11 and 5-12.)

The horizontal motion of the stylus is synchronized with the rotation of the projector, and the density of the record varies directly with the signal strength.

The recorder uses an electro-sensitive paper roll that comes in a sealed plastic container. To install the paper, remove the plastic covering first then place the roll within the recorder in the following manner:

1. Unlock the recorder cover with the two cam lock handles on the cover arms and open the cover. (See fig. 5-13.)

2. Place the roll of paper in the paper supply compartment with the molded paper

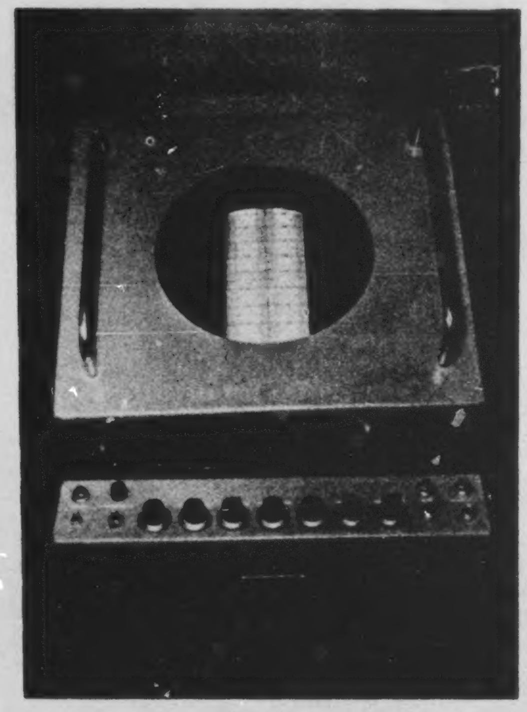


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Figure 5-10.—Cloud height indicator IP-327B/GMQ-13 showing controls and CRT with cover in place.

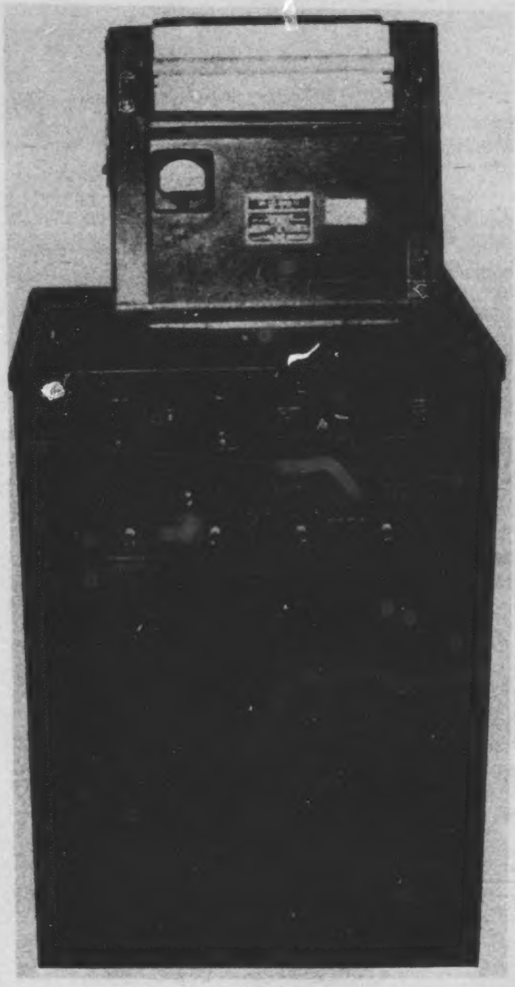

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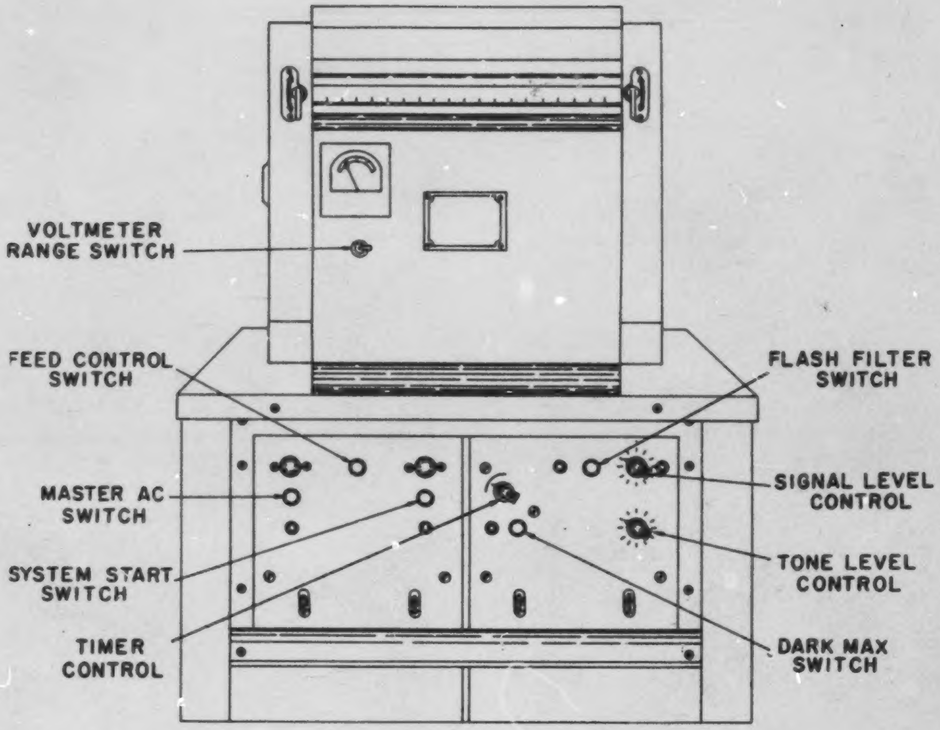
Figure 5-11.—Cloud height recorder RO-121/GMQ-13.


VOLTMETER RANGE SWITCH
FEED CONTROL SWITCH
MASTER AC SWITCH
SYSTEM START SWITCH
TIMER CONTROL
FLASH FILTER SWITCH
SIGNAL LEVEL CONTROL
TONE LEVEL CONTROL
DARK MAX SWITCH

209.385

Figure 5-12.—Cloud height recorder RO-121/GMQ-13 showing controls.

hubs engaging the two slots of the paper holder in the paper supply compartment so that the paper unrolls from the top.

3. Pull the paper up and over the top of the recorder, putting the end of the paper in the slot of the take-up roller (See fig. 5-13.) Make one or two turns on this roller as in camera film loading. The take-up roller is removed from the take-up roller assembly by pushing the roller to the left and disengaging the nylon drive rachet on the right end of the roller from the drive source.

4. Close cover and secure cam lock handles. Make sure the paper is flat, smooth, and moist.

To obtain a cloud height value from the recorder, place the "Dark Maximum" switch in the "ON" position, and read the left-hand edge of the "Dark Maximum" pulse on the paper that corresponds to the angle reading on the lucite window cover. This angle is then converted into a height value from the table posted on or near the equipment.

Maintenance

Routine preventive maintenance consists of making weekly checks on the major components of Cloud Height Set AN/GMQ-13( ). Checks

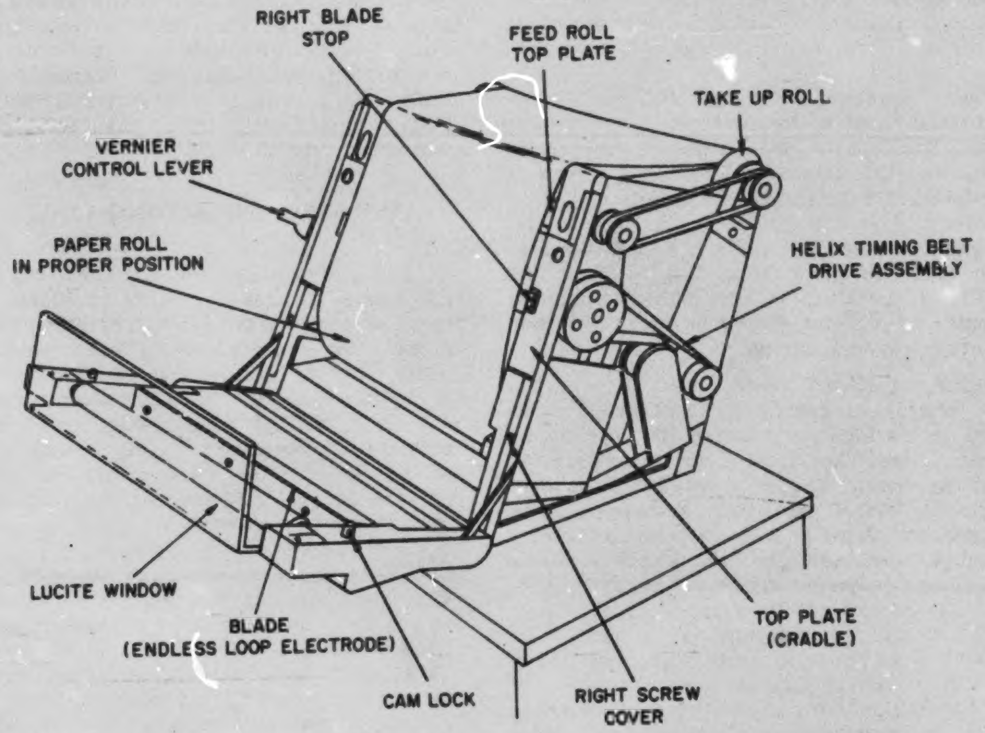

RIGHT BLADE STOP
FEED ROLL TOP PLATE
TAKE UP ROLL
VERNIER CONTROL LEVER
PAPER ROLL IN PROPER POSITION
HELIX TIMING BELT DRIVE ASSEMBLY
LUCITE WINDOW
BLADE (ENDLESS LOOP ELECTRODE)
TOP PLATE (CRADLE)
CAM LOCK
RIGHT SCREW COVER

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Figure 5-13.—Cloud height recorder RO-121/GMQ-13 with door open and showing paper installation.

are to be made regularly by station electronics personnel. The check should be made on or about the same day each week in order to realize the greatest benefit. It is the responsibility of the meteorologist in charge to see that these checks are made and to take necessary action to keep the equipment in operation. Cleanliness of the recorder and indicator is maintained by the Aerographer's Mate operators.

RECORDER.—Check inside recorder cover for dust and clean if necessary. This condition will vary depending on periods of idleness. Clean the plastic portion of the recorder cover using a soft cloth to prevent scratching.

INDICATOR.—Clean the air intake below the front door by removing the mesh cover and blowing or brushing dirt from the mesh. The cover may be removed by prying it from the cabinet with a screwdriver. Clean the plastic cover with a small piece of cloth moistened with water. Because the cover is plastic, it must be wiped lightly to avoid scratching.

BALLOON DETERMINATIONS

The standard balloon specifically designed to measure the height of clouds (ceiling) is the 10-gram, black or dark blue ceiling balloon. The ceiling balloon is normally used to determine the height of the ceiling when the broken or overcast layer of clouds is 2,500 feet or less. Sometimes, it is desirable to obtain a more rapid ascent than can be obtained with a 10-gram balloon; for instance, when taking a balloon ceiling under adverse wind conditions. Under adverse conditions, or when it is necessary to save time, it is permissible to use either a 30-gram balloon or a 100-gram balloon, depending on the desired ascension rate. When using either of these two balloons, choose the appropriate color of balloon; use red balloons for thin clouds and black balloons under other conditions.

The Universal Balloon Balance (ML-575/UM) is used to inflate the 10-gram ceiling balloon for use. The nozzle lift should be so adjusted that it weighs EXACTLY 43 grams when inflating the balloon with helium.

Since the ceiling balloon is not used to reach altitudes much beyond 2,500 feet, the rapidity of inflation is not highly important; however, an attempt should be made to inflate it in about 3/4 to 1 minute.

Ceiling balloons should be stored in a dry, warm environment. The temperature should be as high as possible, but should not exceed 120°F. When the balloons have been exposed to temperatures below freezing, they should be stored at a temperature of 65°F or higher for at least 12 hours prior to removal from their container. They should not be placed immediately adjacent to large electric generators or motors. Motors and generators emit ozone, which is detrimental to neoprene. Balloons lose their strength with age; therefore, they should be used in the order of their production dates to avoid excessive aging. Ceiling balloons need not be conditioned prior to use.

When using a ceiling balloon, note the length of time (use a stop watch or any watch having a second hand) that elapses between the release of the balloon and entry into the base of the layer. The point of entry is considered as midway between the time the balloon first begins to fade and the time of complete disappearance. Determine the height above the surface corresponding to the nearest 5 seconds of elapsed ascent time from tables found in FMH-1. The accuracy of this height will be affected when the balloon does not enter a representative portion of the cloud base; when it is used at night with a light; or if obtained during the occurrence of hail, ice pellets, freezing rain, or moderate to heavy rain or snow.

VISIBILITY MEASURING EQUIPMENT

The Transmissometer AN/GMQ-10 is the only type of visibility measuring equipment in general use throughout the Navy. It provides data through two separate readout components, the Indicator-Recorder, Transmissometer 1D820/GMQ-10C (Indicator, Transmissometer 1D353/GMQ-10B) for visibility indications, and Converter-Indicator Group OA-7900A/GMQ-10 for runway visibility indications.

TRANSMISSOMETER AN/GMQ-10( )

Transmissometer Set AN/GMQ-10( ) is an electronic instrument which provides a continuous record of the atmospheric transmission between two fixed points. The horizontal visibility may be determined by the application of conversions to these measurements. The operation of the transmissometer is nearly automatic, requiring only occasional attention of an operator to make minor adjustments. It uses 115-volt, 60-hertz alternating current for its source of power.

The transmissometer is designed to provide visibilities in the range of 0.05 to 2 miles in the daytime and 0.1 to 2 miles in the nighttime when a 500-foot baseline is used. For visibilities greater than these, the indication is generally good, but the accuracy of the visibility measurements decreases with increasing visibility.

Components

The transmissometer set may be conveniently divided into the following systems. Each of these systems is constructed as a separate unit.

The PROJECTOR consists of an alignment system and a sealed-reflector lamp operated at a constant intensity. The projector directs a light beam of constant intensity toward the receiver. The amount of light reaching the receiver varies with the density of the fog or haze in the path between these two instruments. (See fig. 5-14.)

The PROJECTOR POWER SUPPLY furnishes power at a regulated voltage to the projector for the lamp filament. Facilities are provided for making checks by turning the power off automatically at fixed intervals and off manually from the indicator.

The RECEIVER consists of a telescope to collect light from the projector, and a

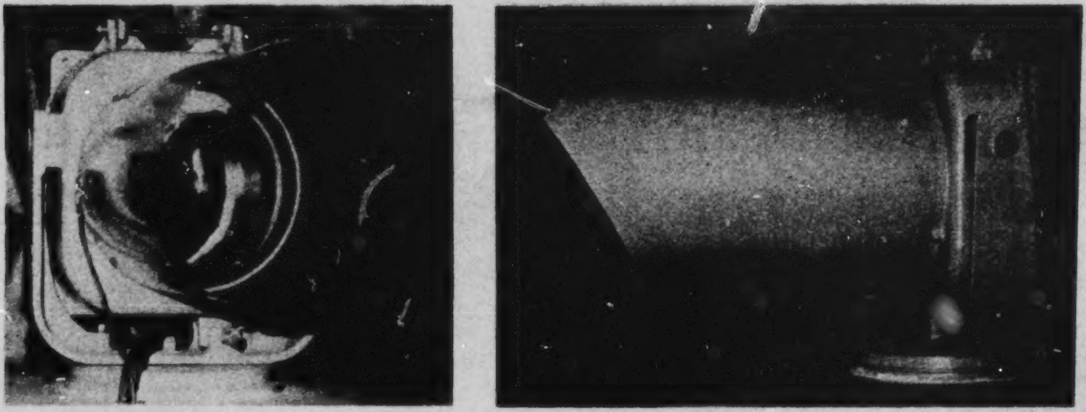

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Figure 5-14.—Projector, transmissometer ML-471/GMQ-10( ) front and side views.

photoelectric detector within the telescope, which generates a pulse signal. At the same time the receiver excludes most of the light from the background. The pulse rate is proportional to the amount of light falling on the receiver. (See fig. 5-15.)

The AMPLIFIER-POWER SUPPLY unit provides regulated voltage for the photoelectric receiver and amplifies the pulse signal of the receiver for transmission to the indicator. A metering unit is also provided to facilitate field adjustment.

The INDICATOR is essentially a frequency meter which converts the pulse signal to a direct current which is proportional to the pulse rate and hence to the transmission.

The RECORDER provides upon a strip chart a continuous record of the output of the indicator. An auxiliary pen indicates the sensitivity range on which the indicator is operating.

In all models of Transmissometer AN/GMQ-10( ), the indicator and recorder are housed in a single unit, which is known as the indicator-recorder.

The CABLE TERMINAL CHAMBERS, of which there are two with each set, act as a housing and a junction for all cabling used in the set. One cable terminal chamber is mounted on the projector stand, and the other is mounted on the receiver stand.

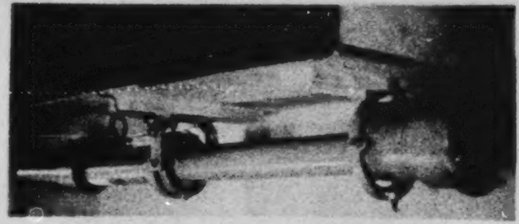

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Figure 5-15.—Receiver, transmissometer R-970/GMQ-10( ).

A typical installation of the transmissometer, showing the various component parts, is shown in figure 5-16.

Operation

Since the initial starting of the transmissometer involves several calibrations and adjustments not ordinarily performed by Aerographer's Mates, the starting procedures for the set are not given here. Once the set is in operation, no further on-off switching is necessary. When the set is placed out of operation or is not operating properly, electronics personnel usually handle the shutdown, repair, and restarting. Operational instructions given here cover only those performed by Aerographer's Mates.

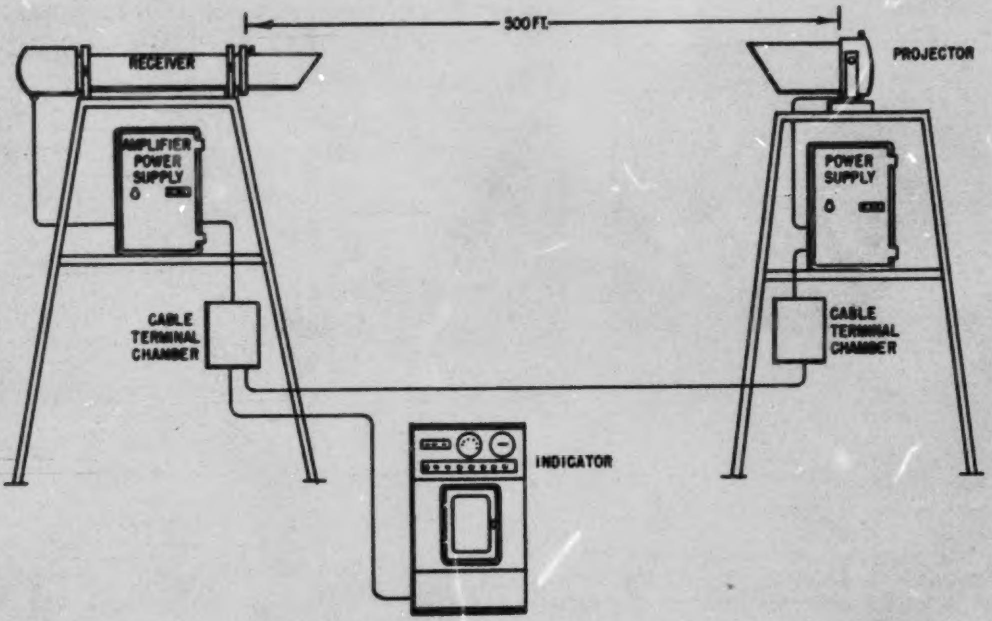

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Figure 5-16.—Typical installation of Transmissometer AN/GMQ-10( ).

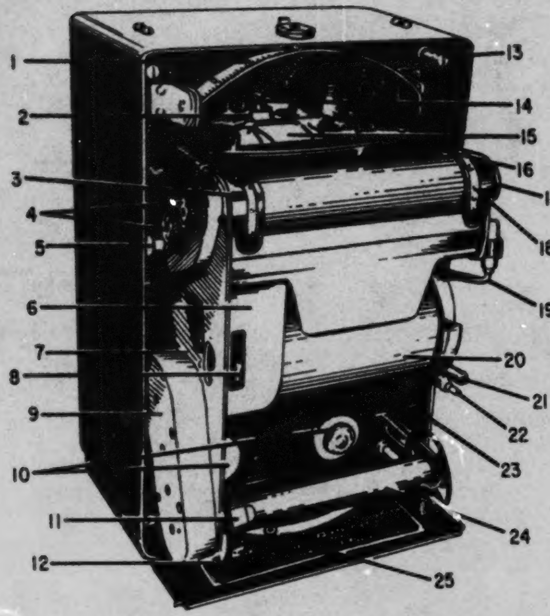
CHART INSTALLATION.—Figure 5-17 shows the recorder with its component parts identified, and figure 5-18 illustrates the proper method of installing the chart.

WRITING SYSTEM.—The pen mechanisms of the recorder have been properly adjusted and under normal conditions should not need readjustment.

To ink the system, lift out the inkwell by lifting the two handles and pulling the inkwell forward. Fill the inkwell about three-fourths full through the pen opening, using the inkwell filler and the ink furnished with the equipment. Use ink ONLY of the type furnished. Do not use standard writing ink or ink intended for use with other types of recording mechanisms. These may clog the pens. Replace the inkwell, being careful that it is under the spring clips which hold it in place. Do not spill ink on the instrument. Remove any spilled ink with a rag or blotter immediately. If ink is spilled on clothing, wash it out as soon as possible, using warm water and soap.

Set the pen element on the pen fork properly, with the knife edges of the element seated in the slots in the fork. Fill the pen by use of the pen filler furnished with the equipment as follows: Compress the bulb of the pen filler; insert the glass pen tip into the hole in the rubber tip of the filler; let the filler suck ink up into the pen until no air bubbles can be seen; and remove the pen element from the filler. Use a blotter between the pen and chart to protect the chart.

Check the balance of the pen by tapping lightly on the chart near the pen. (The pen was properly balanced before shipment.) The pen should bounce up and down on the chart when properly balanced. If the pen pressure is too great, the pen will tend to drag toward the center of the chart, write a heavy line, and slow the response speed of the instrument. If the pressure is too light the pen will write intermittently. The balance of the pen is determined by the position of the pen counterbalance threaded on the back of the pen. No effort should be made to balance the pen unless it is properly filled with ink.



1. Scale plate.
2. Pen element.
3. Paper guide.
4. Change gears.
5. Coupling shaft.
6. Front cover plate.
7. Control lever.
8. Escapement.
9. Reroll gearcase.
10. Extra change gears.
11. Reroll disc clip.
12. Reroll disc.
13. Chart drive mounting screw.
14. Pen fork.
15. Inkwell.
16. Marker pen.
17. Chart set wheel.
18. Drive roll pins.
19. Winding crank.
20. Main spring assembly.
21. Winding arbor.
22. Detent plunger.
23. Chart button.
24. Reroll roller.
25. Zero adjustment.

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Figure 5-17.—Recorder with mounting flange removed (parts identified).

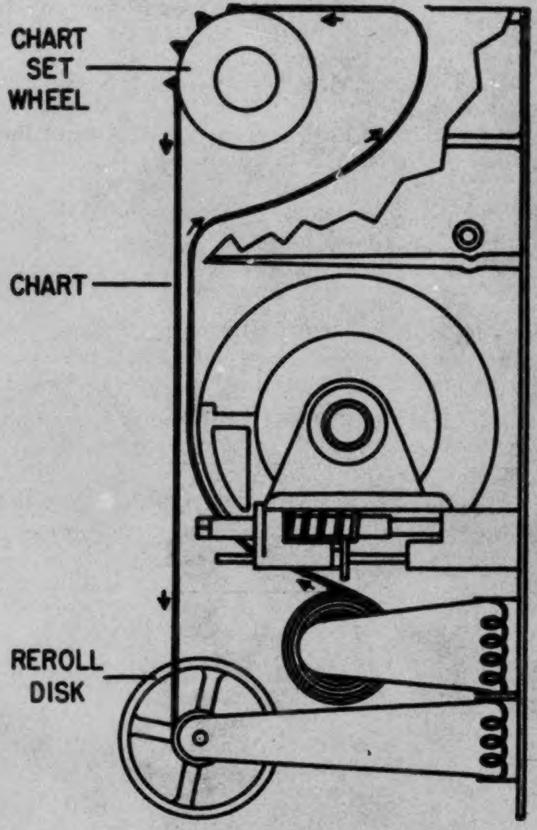

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Figure 5-18.—Proper method of chart installation.

The marker-pen element and the cap are made together and may be separated from the inkwell by unscrewing the cap. After filling the inkwell and replacing the pen element, ink should be drawn into the pen in the same manner as was used for the main pen.

Place the marker pen in its holder on the right side of the meter, making certain that the fork of the pen element is over the actuator bar of the solenoid. Lower the scale plate into position. Swing the pen across the chart several times to make certain that it writes and does not rub the inkwell or scale plate at any position. The indicating target must not touch the scale plate.

If the writing pen is not exactly on zero, tap the chart in front of the pen to ensure the pen is not being held back by drag. If the pen is still not on zero, adjust the mechanical zero of the recorder by moving the ZERO ADJUSTMENT lever on the bottom of the case in the direction toward which the pen needs to be moved. Frequent, gentle tapping of the chart will eliminate pen drag.

INDICATOR CONTROLS.—Controls (fig. 5-19) used in normal operation of the indicator of the transmissometer set are as follows:

1. TRANSMISSION METER. Indicates in percent the atmospheric transmission between the projector and receiver.

2. POWER SWITCH. Connects (ON position) or disconnects (OFF position) power to indicator units.

3. BACKGROUND SWITCH. In TEST position, shuts off projector lamp to determine the amount of background illumination.

4. ZERO SWITCH. In TEST position, shorts input signal to ground for check on electrical zero of the indicator.

5. CALIBRATE SWITCH. In CALIB position introduces line frequency to calibrate circuit.

6. RANGE SWITCH. Selects HIGH or LOW sensitivity range of indicator, actuates marker pen, which indicates sensitivity range on roll chart. (When RANGE switch is in HIGH position, sensitivity is five times as great as when switch is in LOW position.)

7. ZERO ADJUSTMENT POTENTIOMETER. Provides adjustment of electrical zero of indicator and recorder. Clockwise rotation causes needle of transmission meter and recorder pen to move up-scale.

8. CALIBRATION ADJUSTMENT POTENTIOMETER. Provides adjustment so that transmission meter and recorder will read 90 when the pulse rate of the signal it is receiving is 3,600 pulses per minute with range switch

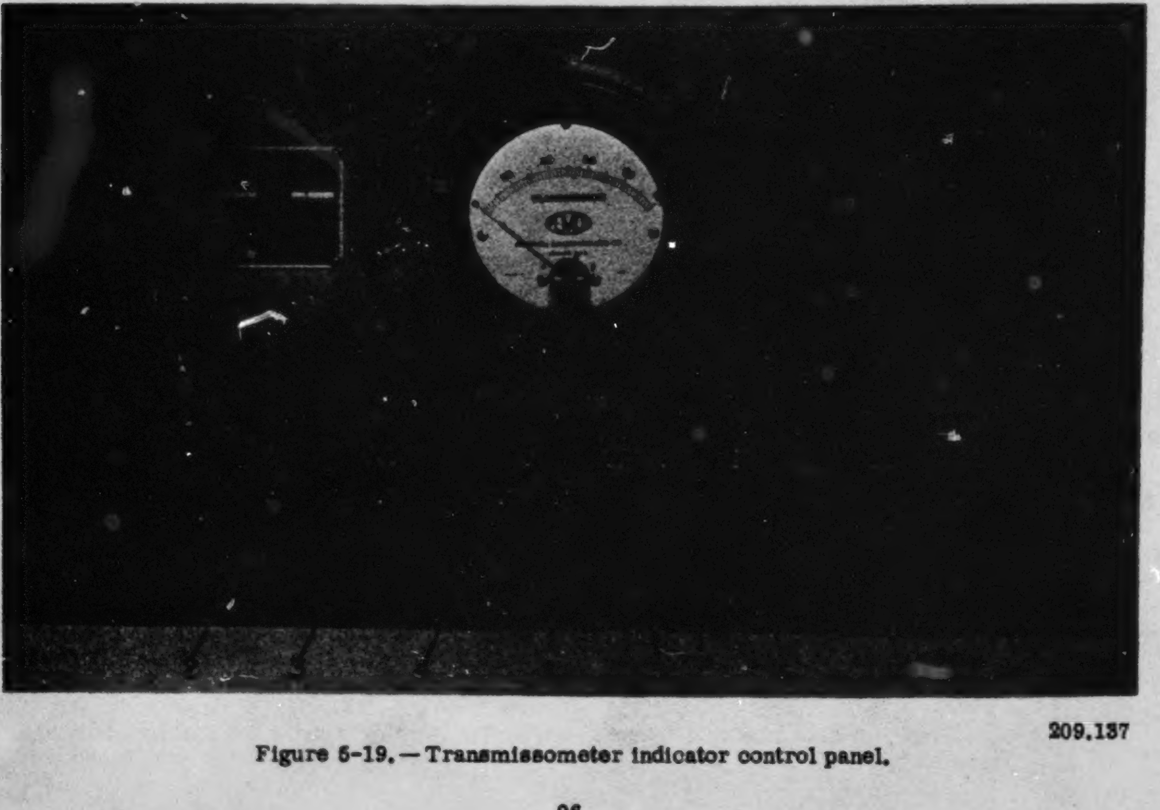

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Figure 5-19.—Transmissometer indicator control panel.

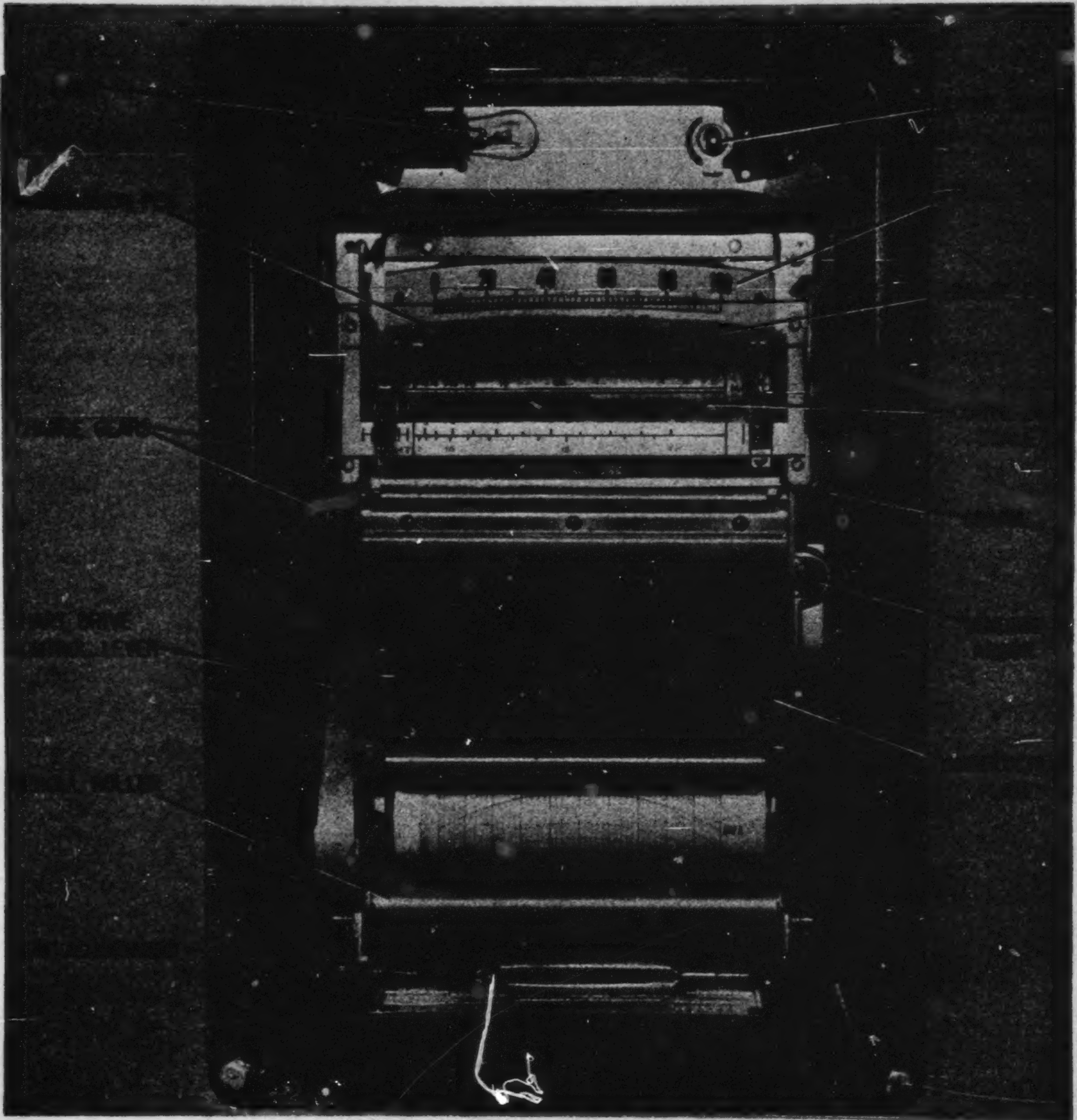

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Figure 5-20.—Transmissometer recorder with door open.

in LOW position. Clockwise rotation causes needle of tramission meter and recorder pen to move up-scale.

RECORDER CONTROLS.—The following controls are used in the operation of the recorder section of the transmissometer. The recorder switch is located in the rear of the indicator unit and puts the recorder meter in movement series with the transmission meter when in the ON position. For the other controls see figure 5-20.

1. ZERO ADJUSTMENT LEVER. Adjusts mechanical zero. Recorder pen moves in same direction as lever.

2. TRANSMISSION PEN. Draws inked line on chart paper according to variable transmission of airpath between projector and receiver.

3. RANGE PEN. Records the position of the range switch on the chart.

4. CHART DRIVE CONTROL LEVER. Turns chart drive clock mechanism on or off. To start mechanism, move lever from Stop to Start. If it does not start, repeat until it starts.

5. CHART DRIVE CHANGE GEARS. Determines the speed of the roll chart. Normal chart speed is 3 inches per hour.

Maintenance

The maintenance which Aerographer's Mates perform on the transmissometer set is of a mechanical nature. The ship's or station's electronics division performs the required maintenance on the electronic components.

PREVENTIVE MAINTENANCE.—To remove corrosion, use very fine sandpaper. Never use emery cloth or steel wool within the cabinets at any time, since the debris from these materials are conductors and can cause shorts between components.

Keep both the interiors and exteriors of the units clean. Use cheesecloth to clean the cabinets and either cheesecloth or a camel's hair brush to clean electrical components. If necessary, except for electrical contacts, moisten the cloth or brush with an approved drycleaning solvent. After cleaning the parts dry with a clean cloth.

When cleaning the lenses, harsh or gritty cleansers should be avoided. A soft, lint-free cloth and clean water will usually be satisfactory. When this is not sufficient, use a mild cleanser meeting the Navy's standards. Do not use cleansers which will leave an oily residue on the glass. The cleaning process should end with a dry, clean, film-free, deposit-free, glass surface.

LUBRICATION.—The indicator and recorder require semi-annual lubrication; the projector, projector power supply, and receiver require annual lubrication. Specific instructions are contained in the technical manual for the equipment.

If the parts listed are gummy or excessively dirty, clean with an approved drycleaning solvent before oiling.

CONVERTER-INDICATOR GROUP OA-7900A/GMQ-10( )

Runway Visual Range (RVR) is a measurement of the visibility along the runway through the use of Converter-Indicator Group OA-7900A/GMQ-10 in conjunction with the Transmissometer AN/GMQ-10. RVV is an instrumentally derived value that represents the horizontal distance a pilot will see down the runway from the approach end. Even though the equipment is termed RVR converter, it is used to obtain RVV and not RVR.

Converter-Indicator Group OA-7900A/GMQ-10 consists of Signal Data Converter CV-3125/GMQ-10 and Digital Display Indicator ID-1939/GMQ-10 as shown in figure 5-21.

Theory of Operation

As mentioned in the foregoing paragraph, this equipment utilizes data from the Transmissometer AN/GMQ-10 for the computation of Visibility (RVV). The transmissometer supplies light transmittance signals in the form of pulse rates. These pulse rates are transmitted to the RVR converter where they are correlated with the empirically obtained visibility data encoded therein. The corresponding visibility value is then displayed once every minute.

The system is designed to convert the transmittance pulse rates to their corresponding visibility values with a high degree of accuracy.

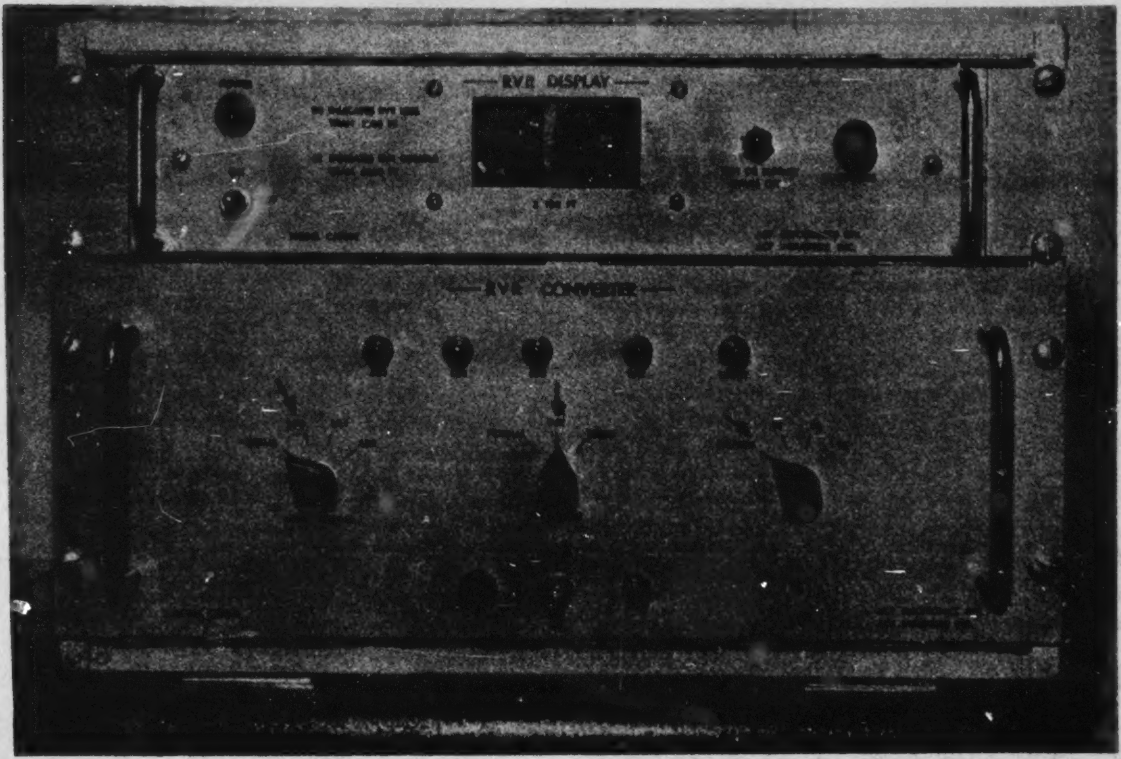

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Figure 5-21.—Converter-Indicator Group OA-7900A/GMQ-10.

They are based on a 500-foot baseline between the transmissometer projector and receiver.

The visibility system will convert pulse rates from transmissometer sets of other baselines provided the visibility values to be displayed are properly related to the pulse rates, and encoded on the encoder disc.

The visibility values are displayed digitally in increments of 200 feet ranging from 1,000 to 6,000 feet. Values less than 1,000 and greater than 6,000 feet are displayed as 800 feet and 6,200 feet respectively. Actually, the values are displayed as two-digit numbers which should be multiplied by a factor of 100 in order to obtain the correct reading. When the equipment is tested or the runway lights are OFF the red light indicator on the display panel is ON. Consequently, the displayed values should not be accepted as true values of RVR.

SIGNAL DATA CONVERTER CV-3125/GMQ-10.—The Signal Data Converter is designed for rack mounting. Mounting slides are provided with the unit to enable forward withdrawal from the rack in order to gain easy access to its interior. The chassis is completely enclosed to prevent foreign objects from falling inside, which may cause shorts and general damage. All switches are located on the front panel and all connections are in the rear.

The controls are shown in figure 5-21 and perform the following functions:

1. POWER switch. Switches ac power to unit.

2. RUNWAY LIGHT SETTING selector. Selects applicable RVR curves or places equipment in NORMAL OPERATE condition.

3. DAY-NIGHT selector. Places equipment in DAY, NIGHT, or NORMAL.

4. MODE selector. Places equipment in NORMAL OPERATE condition or in one of three test conditions.

5. LS3, LS4, and LS5 indicators. Illuminated indicator identifies RVR curve in use.

6. NIGHT indicator and DAY indicator. Illuminated indicator identifies RVR curve in use.

To observe proper operation of the Converter-Indicator Group the transmissometer must be turned ON. All control switches on the converter should be set to NORMAL position. With the power switch in the ON position, check the fan in the back of the unit to make sure that it is running and the filter is not touching the blade. The remotely selected light setting on the front panel (selected at the runway or tower) should be indicated by the appropriate light indicators, after the appropriate control settings as presented in the OPERATORS MANUAL have been set.

DIGITAL DISPLAY INDICATOR, ID-1939/GMQ-10.—The Digital Display Indicator can be rack-mounted or placed on a desk top for convenience of the observer. It is also completely enclosed for protection against foreign objects. All controls are located on the front panel. Interconnection of the converter and display made in the rear. The front panel controls are shown in figure 5-21 and perform the following functions:

1. ON-OFF TEST switch. Applies ac power to unit in TEST position or in ON position when RVR converter is turned on.

2. TEST or RUNWAY LIGHTS OFF indicator. Illuminated indicator informs operator that equipment is either in a test condition or that no RVR curve for runway lighting has been selected.

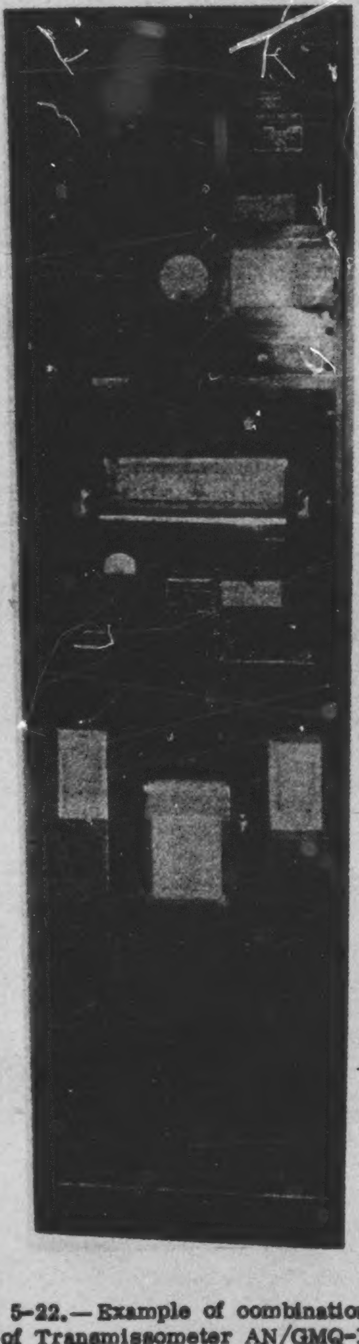

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Figure 5-22.—Example of combination installation of Transmissometer AN/GMQ-10, RVR Converter-Indicator Group OA-7900A/GMQ-10, and Cloud Height Set Recorder RO-121/GMQ-13.

3. BRIGHTNESS control. Adjust the brightness of the RVR display.

Make sure that all cables are connected properly. Turn the BRIGHTNESS knob fully clockwise. The display screen should now be illuminated. The observer should wait 2 minutes before observing the displayed digits.

The power requirements for the Converter-Indicator Group are 115 ± 10 volts ac, 60 hertz, with a three-prong outlet providing 1.0 amps for the Signal Converter and a two-prong outlet providing 0.3 amps for the digital Display Indicator.

Test Equipment

Maintenance specialists who have been trained and are familiar with this equipment will perform the necessary tests and operational and field maintenance on this equipment. More details concerning operation and maintenance of this equipment are contained in the equipment manual which should accompany the equipment.

Office Installation

The Transmissometer AN/GMQ-10 ( ) and Converter-Indicator OA-7900A/GMQ-10 ( ) readout units are generally mounted in a standard 19-inch communications rack in any combination. This installation may also combine the Cloud Height Set Recorder RO-121/GMQ-13 ( ) without its stand in order to conserve space. (See figure 5-22.)

NOTE: Changes to all column numbers and entries on NWSC Form 3140/8 were received too late for inclusion in this manual. Where errors in column numbers appear, refer to the U.S. Navy Supplement to FMH #1, Chapter 13, Marine Aviation Observations for the most recent amplifying instructions.

CHAPTER 6

RADAR AND SATELLITE EQUIPMENT

Two of the biggest forecasting aids that present immediate pictorial depiction of meteorological data to the meteorologist are satellites and weather radars. This chapter is devoted to introducing the Aerographer's Mate to the various types of satellites and weather radar equipment being used by Naval Weather Service personnel today.

RADAR EQUIPMENT

Radar and weather are very closely allied. The use of radar has provided meteorologists with a tool which permits the collection of atmospheric data under conditions when the more orthodox methods fail. On the other hand, a knowledge of atmospheric conditions provides the radar operator with information vital to the accuracy of his results.

The word radar is an acronym for "radio detection and ranging." Fundamentally, all radar depends upon the emission of a short, sharp pulse of electromagnetic energy in a given direction. This pulse on intercepting a target is scattered in all directions. That part of the energy which is scattered in the direction of the radar is picked up by the radar antenna, producing an echo or "blip" on the receiver scope. The time taken for the pulse to cover the path to the target and return is a measure of the range to the target. Azimuth and elevation of the target are determined from the direction in which the pulse is emitted and returned.

Since the electromagnetic pulse travels with the speed of light, range is determined by a timing procedure. At the instant the pulse leaves the antenna, a timing device starts counting. When the return echo reaches the antenna, the counting is stopped. The distance to the target is equal to one-half the distance traveled by the pulse.

Meteorological radar provides a unique means of obtaining meteorological data for use by the forecaster when issuing warnings and environmental forecasts. As weather requirements continue to expand and change, new designs and modifications to meteorological radar will continue to appear in the effort to improve and keep pace.

The Meteorological Radar Set AN/FPS-106 is the newest model of radar designed for meteorological use. The AN/FPS-81 meteorological radar is the most common set in use in the Navy today.

RADAR INDICATORS

The purpose of the indicator (cathode ray tubes) in a radar is to display information to the Aerographer's Mates about the range, bearing, and elevation of surrounding targets. In general, information is presented piecemeal, and a single viewing of an indicator gives only a small part of the picture. Different types of radar scans are employed to display wanted information from returning echoes on the different indicators.

A-Scan Presentation

The simplest type of display is the A-scan presentation, which is illustrated in figure 6-1. The display is one which gives return signal intensity against range. This display shows only the range to a target.

The bearing of the target can be found by moving the antenna horizontally to the position of maximum signal intensity (highest pip). Changing the angle of elevation of the antenna to get maximum signal intensity provides information concerning the elevation of the target. The horizontal and vertical limits of a rainstorm can be found in much the same way by noting the positions of the antenna at which the return drops below a detectable level.

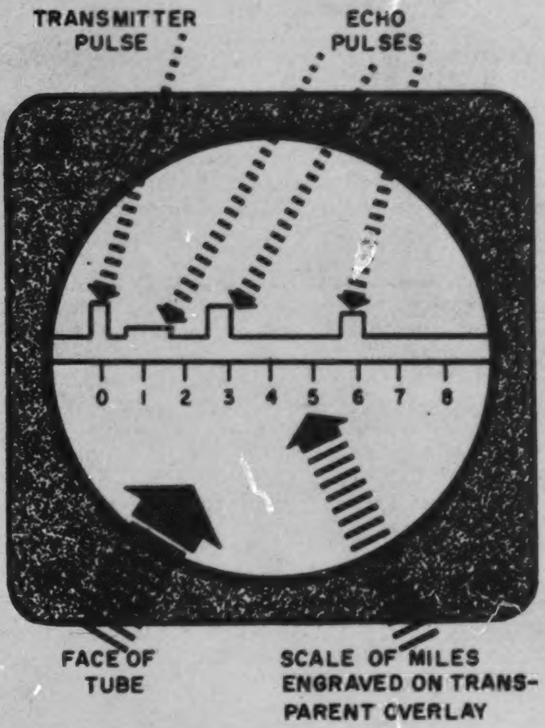

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Figure 6-1.—General appearance of A-type scan presentation as it would appear on the range indicator CRT.

R-Scan Presentation

The R-type scan is almost identical to the A-type. The difference between the two is that the A-scan presentation displays the total range starting at 0 range and ending at any one of several ranges selected; the R-scan presentation isolates a portion of the range scale and expands it.

PPI-Scope

Another type of display commonly used in radar is termed Plan Position Indicator (PPI). This display makes it possible to read range and bearing information simultaneously. A diagram of a basic PPI-scope is shown in figure 6-2.

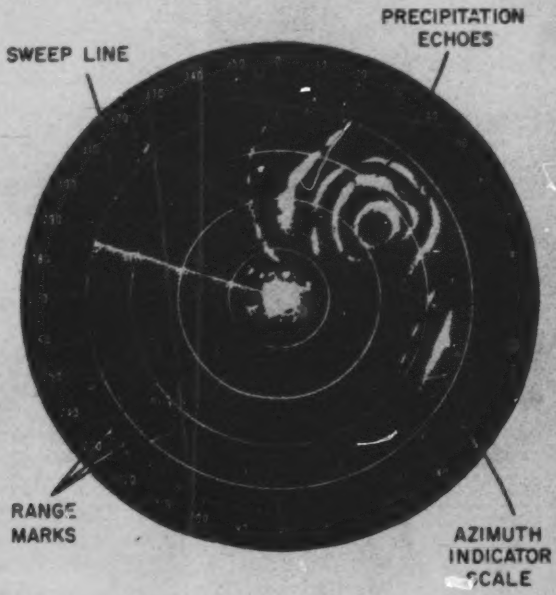

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Figure 6-2.—Diagram of PPI-scope.

In essence, with the PPI-scope, the sweep starts at the center of the tube instead of at one edge as it does on the A-scope. As the antenna rotates around a 360° circle, the sweep rotates simultaneously. The intensity of the sweep display is modified by the presence of a return signal. Thus, the position of a target is indicated at the correct azimuth and range by a bright spot on the display tube. A map-like picture is thereby produced on the tube as the antenna rotates in the azimuth plane.

RHI-Scope

The Range Height Indicator (RHI) is another scope found on radar equipment. Its function is not unlike that of the PPI except that when this scope is used, the azimuth of the antenna is kept fixed while the antenna moves from viewing at 0° elevation to a predetermined elevation.

Range Markers

Each of the conventional scopes provides for some direct indication of range by display of range markers. The range markers may be turned on or off and may be varied.

Factors Affecting Radar Performance

There are many factors, or elements, that affect efficient radar performance, not all of which are completely understood. Many of the limitations of the equipment are a result of radar design.

RADAR SET AN/FPS-81

Meteorological Radar Set AN/FPS-81 is a ground-based radar system used to establish the geographic locations of storm centers relative to a fixed base reference site. The equipment is capable of detecting storm centers within a radius of 200 nautical miles. Radar echo signals from concentrations of high moisture content are presented on cathode-ray tube (CRT) indicators in such a manner as to convey the positions of storms in terms of azimuth, slant range, and elevation (height). The radar echo signals may be displayed with iso-echo contouring, if desired, to provide maximum clarification of storm configurations.

Limitations

The antenna may be made to scan manually in both planes (azimuth and elevation) simultaneously, or it will scan automatically in one plane while manual search is conducted in the other. The antenna will not scan automatically in both planes simultaneously. Radar targets will not normally be visible at less than a 1-mile range.

Component Parts

Meteorological Radar Set AN/FPS-81 consists of an antenna assembly, a Receiver-Transmitter-Modulator (RTM) assembly, an indicator console, and a remote indicator assembly. (See fig. 6-3.) The major portion of the system circuitry is contained in modular units of the plug-in type to simplify and expedite maintenance procedures.

ANTENNA ASSEMBLY.—(fig. 6-3 (D)) Radar illumination of target areas is provided by the antenna which directs and concentrates the high-level RF (radiofrequency) energy into a narrow beam. Radar echoes are returned from target areas to be detected by the antenna and fed to circuits throughout the system.

Control of the antenna may be accomplished manually or automatically.

RECEIVER-TRANSMITTER-MODULATOR (RTM) ASSEMBLY.—The receiver-transmitter assembly (fig. 6-3 (C)) contains the electronic components required to transmit and receive the RF signals.

INDICATOR CONSOLE.—The indicator console, from which the entire system may be controlled and monitored, houses the Range/Height Indicator (RHI), the Plan Position Indicator (PPI), and the Range Indicator as illustrated in figures 6-3 (A) and 6-4.

A power panel on the rear of the indicator console, mounted between the PPI and range indicator assemblies, accepts power for distribution to the entire system.

PLAN POSITION INDICATOR (PPI).—The PPI, located in the center portion of the indicator console, presents range and azimuth information in a plan view (as seen from zenith directly over the radar site).

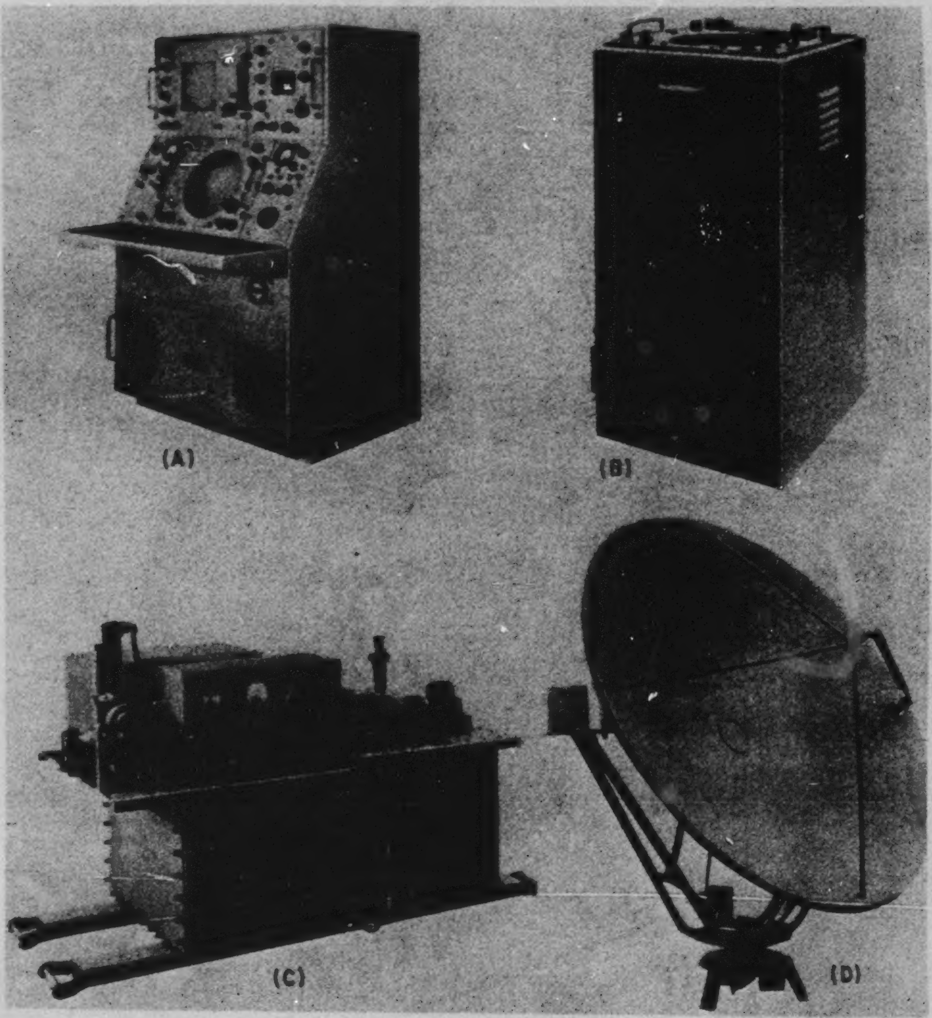
RANGE/HEIGHT INDICATOR (RHI).—The RHI indicator occupies the left side of the indicator console and presents range and height information.

RANGE INDICATOR.—The range indicator, housed in the upper right-hand section of the indicator console, features a standard A-scan tube. Range information (A-scan) is displayed along the horizontal axis of the CRT display.

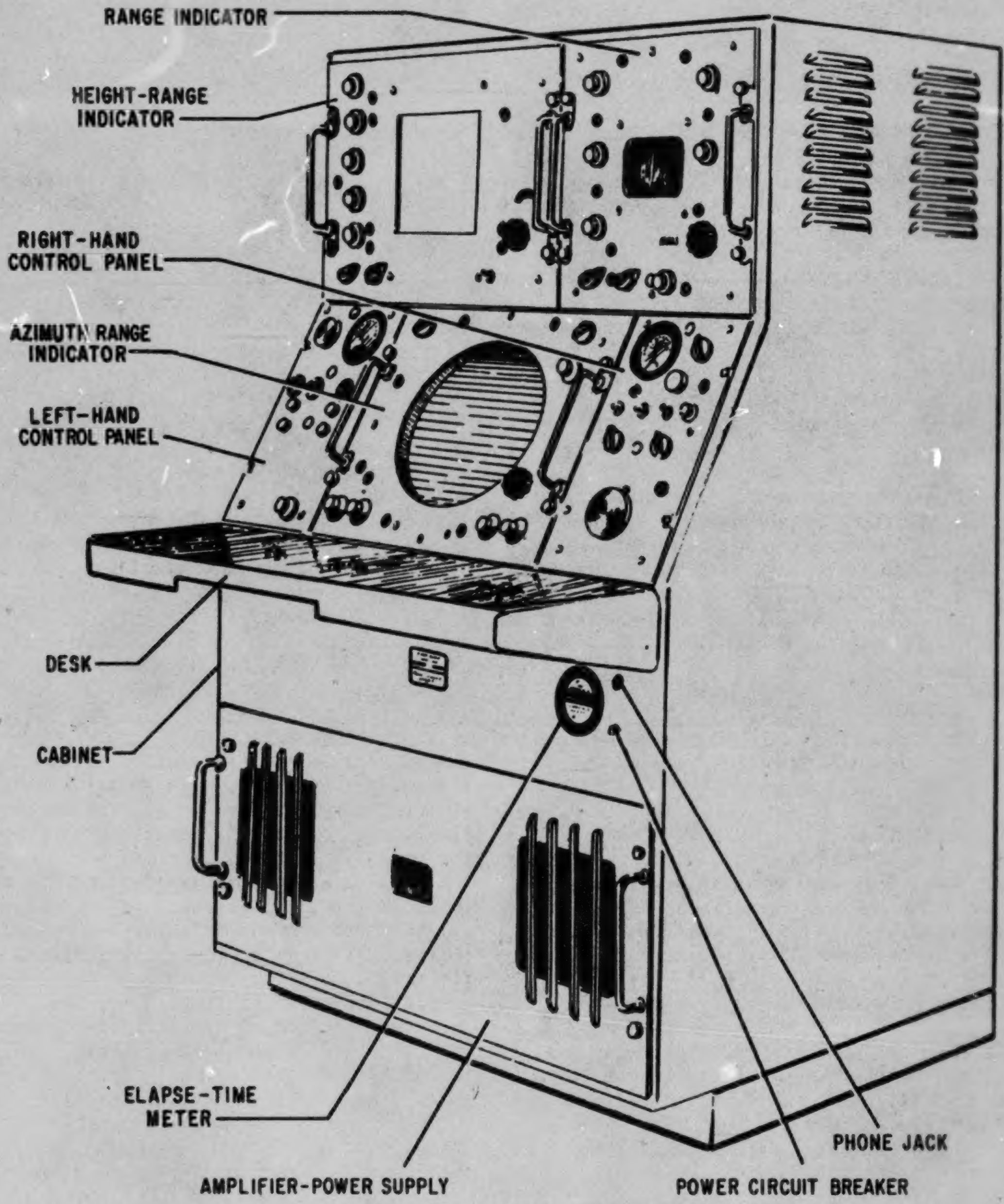
REMOTE INDICATOR.—The remote indicator assembly, figure 6-3 (B), which may be located away from the indicator console, provides a repeat display of the information presented by the local indicator.

RADAR SET AN/FPS-106

Meteorological Radar Set AN/FPS-106(V) is the newest of the Navy weather radars. It can be installed both at fixed locations and in mobile vans to detect and plot movements of storms and other meteorological phenomena. The operating range is to 200 miles with an azimuth scan



210.364
Figure 6-3.—Meteorological Radar Set AN/FPS-81. (A) Indicator Group OA-3871/FPS-81; (B) Indicator Group OA-3872/FPS-81; (C) Receiver-Transmitter, Radar RT-658/FPS-81; (D) Antenna Group OA-3870/FPS-81.


RANGE INDICATOR
HEIGHT-RANGE INDICATOR
RIGHT-HAND CONTROL PANEL
AZIMUTH RANGE INDICATOR
LEFT-HAND CONTROL PANEL
DESK
CABINET
ELAPSE-TIME METER
AMPLIFIER-POWER SUPPLY
PHONE JACK
POWER CIRCUIT BREAKER

209.142

Figure 6-4.—AN/FPS-81 Console.

of 360 degrees, and elevation capability of -2 to +60 degrees.

Component Parts

The AN/FPS-106(V) consists of a receiver-transmitter group, a control indicator group, a choice of two antenna systems, depending on the type installation, fixed or mobile, and two radomes. (See figure 6-5.)

ANTENNA ASSEMBLIES.—Both antenna assemblies are electrically similar, but in size they differ. The fixed installation antenna is eight feet in diameter and is used with both the AN/FPS-81 and AN/FPS-106(V) radars. The mobile van antenna is only six feet in diameter and cannot be utilized with the AN/FPS-81 radar set.

RADOMES.—The fixed installation radome consists of rigid segments held together with bolts. A ventilator and lightning rod are mounted on top of the radome providing ventilation and lightning protection. The mobile radome differs from the fixed radome in that it consists of fewer rigid segments, and a segment cover. A lightning rod is provided, but it is not ventilated.

RECEIVER-TRANSMITTER.—The RT group generates the pulses and processes the return signal.

METEOROLOGICAL CONTROL-INDICATOR.—The Meteorological Control-Indicator group (fig. 6-6) displays the received signals in the form of azimuth, range, and elevation information. All operating controls for the radar set are located on the front panels.

Operational Procedures

The initial energization and deenergization are too lengthy for coverage in this manual and are not generally performed by the AG but by the Electronic Technicians attached to the unit. Refer to NAVAIR 50-30FPS-106-1 Manual for description of the procedures in the event that no technicians are available.

Operator Maintenance

In order to maintain a normal equipment operation with a minimum of interruption, operating personnel will check items on a daily basis. These items are outlined in the maintenance manual. The regular practice of these procedures will enable the operators to notice minor deviations from the normal operations. In the event deviations occur, operating personnel will immediately notify the maintenance personnel so that the minor deviations can be remedied before they become major problems.

RADAR FACSIMILE RECORDER AN/GMH-6( )

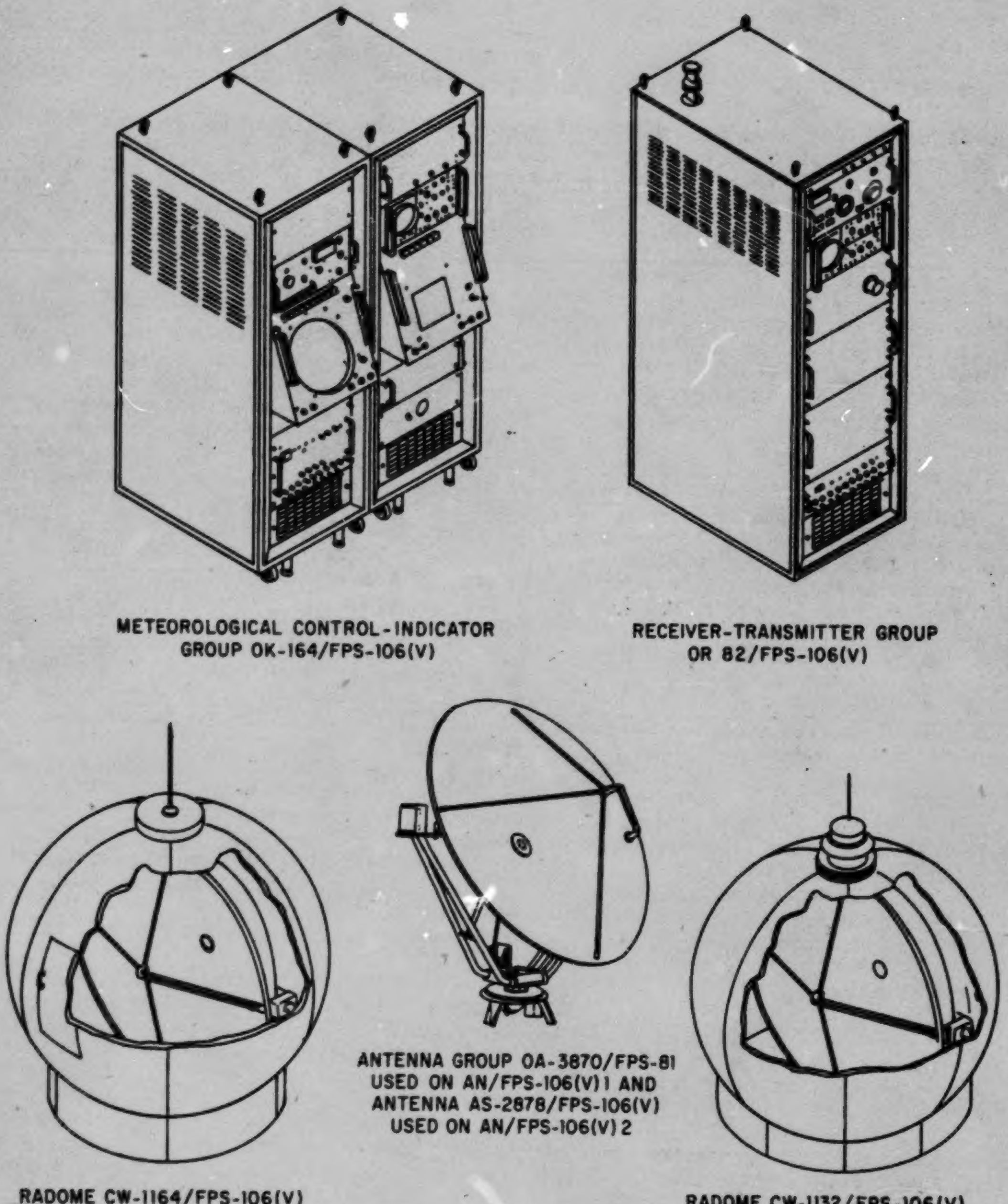
The Radar Facsimile Recorder AN/GMH-6( ) is illustrated in figure 6-7.

This facsimile recorder is used to copy weather data transmitted from the radar/transmitter site where the transmitting device horizontally scans a Plan Position Indicator (PPI) radar scope. The data is then transmitted via telephone line to the recorder. The recorder provides a hard copy printout of the weather pictures, including "data insert information" on a continuous roll of electrolytic paper. The data insert information consists of automatic printing of a time-date code, indicating the day of the year and the time of the day that the particular picture was received and printed.

The recorder has controls that determine the frequency at which consecutive groups of pictures are printed. A group may consist of 1, 2, or 3 pictures. The period between the groups may vary to an infinite number of minutes. A period in this case refers to the length of time from the end of the picture of a consecutive group to the beginning of the first picture in the following consecutive group.

Controls are also provided for the adjustment of printing quality, such as degree of contrast and whiteness. Other controls set the time and data information printed on each weather picture.

As illustrated in figure 6-7, the facsimile recorder consists of the electronic chassis, and the recorder head (printing display area and paper takeup) which are mounted in and on, respectively, one metal console. The console rests on four swivel casters, to permit mobility. The two front casters can be locked to fix the console in a stationary position. The electronic chassis is a slide-mounted pullout drawer which provides for easy removal, servicing, cleaning, and testing of the chassis. The electronic chassis contains all operating controls, fuses, and indicators for the facsimile recorder, except the paper take-up switch and fuse, the paper supply indicating light, and the



METEOROLOGICAL CONTROL-INDICATOR GROUP OK-164/FPS-106(V)

RECEIVER-TRANSMITTER GROUP OR 82/FPS-106(V)

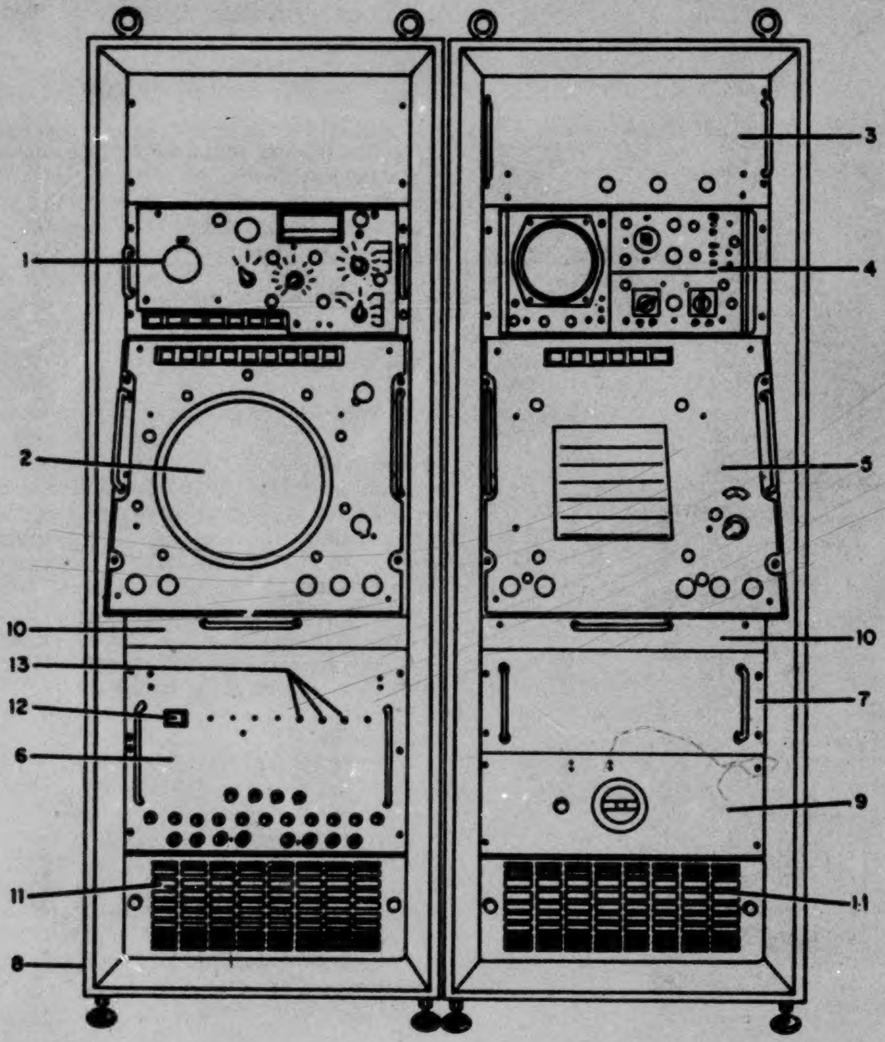
ANTENNA GROUP OA-3870/FPS-81 USED ON AN/FPS-106(V)1 AND ANTENNA AS-2878/FPS-106(V) USED ON AN/FPS-106(V)2

RADOME CW-1164/FPS-106(V) USED ON AN/FPS-106(V)2

RADOME CW-1132/FPS-106(V) USED ON AN/FPS-106(V)1

209.425

Figure 6-5.—Meteorological Radar Set AN/FPS-106(V).



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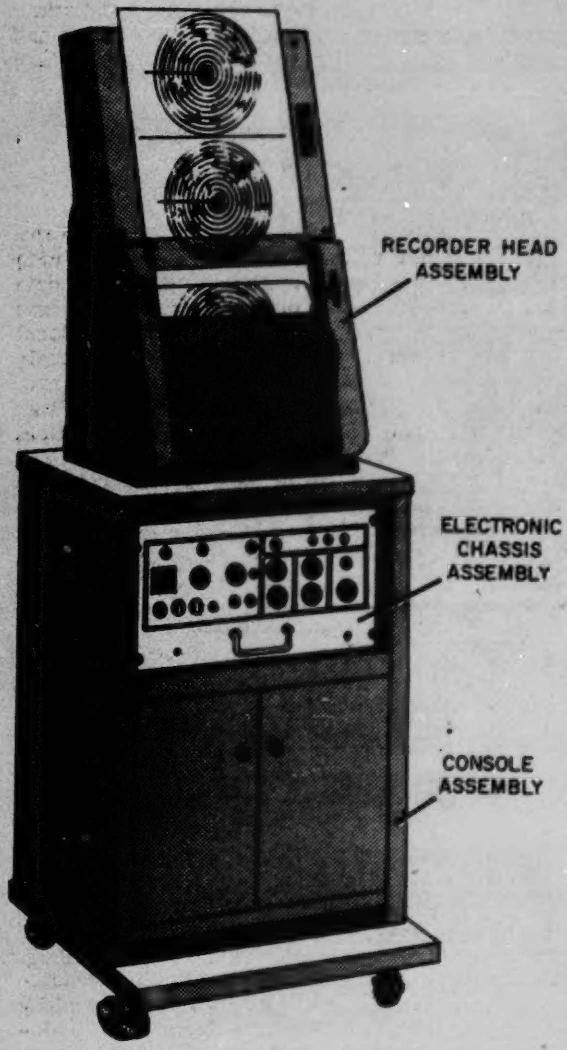
1. Radar Set Control C-8695
2. Azimuth-Range Indicator IP-1055
3. Deflection and Video Amplifier AM-6386
4. Oscilloscope OS-224
5. Height-Range Indicator IP-1056
6. Power Supply PP-6568
7. Electronic Control-Intermediate Frequency Amplifier AM 6387
8. Electrical Equipment Cabinet CY-7009
9. Meter and Power-Indicating Panel
10. Writing and Storage Desk
11. Cabinet Cooling-Air Blower
12. AC Power Push-Button Switch
13. +150 VDC, +300VDC, and -150 VDC Indicator Lamps

Figure 6-6.—Meteorological Control-Indicator Group OK-164/FPS-106(V).



210.366
Figure 6-7.—Radar Facsimile Recorder AN/GMH-6( ).

paper fast feed switch, which are located on the Recorder Head.

Operation

Prior to operation of the Radar Facsimile Recorder, personnel should refer to the publication NAVAIR 50-30GMH6-1. Complete operating instructions are contained in this publication.

Maintenance

Servicing and maintaining this equipment are the responsibilities of trained electronics personnel. As with other complex electronic equipment the maintenance duties of the Aerographer's Mate are limited to keeping the exterior of the equipment clean and promptly reporting any internal difficulties to the responsible parties.

Safety Precautions

High voltage is used in the operation of all radar. Extremely dangerous voltages exist in the receiver, transmitter, modulators, main console, and remote indicator. Death on contact may result if operating personnel fail to observe safety precautions. Only authorized operation of equipment should be carried out by the operator. All operators must know how to secure main power, both remote and locally, to the set in use. All operators must know how to apply artificial respiration and how to contact immediate medical aid.

SATELLITES AND ASSOCIATED EQUIPMENT

Since the launching of the first weather satellites in early 1960, we have witnessed the birth of the meteorological satellite as an unprecedented tool for observing broad-scale global data, and its growth into a highly sophisticated global observation system capable of providing innumerable valuable measurements of interest to the scientific community.

The Television Infrared Observational Satellite (better known as TIROS) that pioneered in worldwide meteorological photography evolved into the ESSA satellite which contained improved camera systems as well as other sensors. Nimbus, a larger, more sophisticated satellite, was designed for the purpose of helping develop instrumentation for long-range weather forecasting. Continuing with the advancement of satellite development, the Applications Technology Satellites (ATS) carried meteorological and communications experiments to a 22,300 mile orbit, from which they provided spectacular full-earth photographs.

As progress continued, TIROS was superseded early in 1966 by the TIROS Operational Satellite (TOS) System. The satellites in the TOS series are referred to as Environmental Survey Satellites (ESSA) which was mentioned previously. The TOS System provided nearly complete global coverage daily, hence a near-continuous record, since its initial launch.

In January of 1970 the beginning of the second decade of weather observation by the use of meteorological satellites was inaugurated with the successful launch of the Improved TIROS Operational System (ITOS) satellite. Satellites in this series are referred to as NOAA (National Oceanic and Atmospheric Administration).

The ITOS combines the proven technology and satellite hardware developed by the TIROS and TOS systems and in addition contains sensors developed through other NASA programs. As a result, all sensors are placed on a single satellite, instead of having a number of separate satellites to accomplish the same purpose. The ITOS system provides both day and night cloud observations.

More recently the Synchronous Meteorological Satellite/Geostationary Operational Environmental Satellite (SMS/GOES) and the Defense Meteorological Satellite Program (DMSP) have become operational providing the latest advances in satellite meteorology.

SATELLITES

The following paragraphs will discuss briefly the various operational satellites in use today along with the equipment utilized by NAVOCEANMET to track and acquire this valuable meteorological information.

Sychronous Meteorological Satellite/ Geostationary Operational Environmental Satellite (SMS/GOES)

This is the latest in a new series of geostationary satellites to be placed in orbit for meteorological data acquisition and relay. They are operational descendents of the ATS which clearly demonstrated that earth-synchronous spacecraft have great value in observing environmental conditions. The satellites are in orbits 22,300 miles above the equator and traveling at speeds that keep them continuously above the same spot on earth. This keeps the same region always in view, and their sensors can watch the entire life cycles of storms and other meteorological phenomena that could develop and die without ever being observed by the polar-orbiting satellites.

Improved TIROS Operational System/ National Oceanic Atmospheric Administration (ITOS/NOAA)

These satellites are under the control of the National Environmental Satellite Service (NESS) and carry three subsystems for acquiring data which is stored on board the spacecraft and also may be transmitted in real-time to local readout stations. They are in a continuously moving polar orbit. The three subsystems are, the Scanning Radiometer (SR), the Very High Resolution Radiometer (VHRR), and the Vertical Temperature Profile Radiometer (VTPR). The SR is used to provide APT services to the numerous low-cost VHF ground receiving stations scattered throughout the world. The VHRR provides High Resolution Picture Transmission (HRPT), and the VTPR provides direct sounding transmissions for atmospheric temperature profiling. All three systems operate continuously day and night. Only the SR system is in general use, while the other systems are receivable only at selected stations having the compatible tracking and receiving equipment.

Defense Meteorological Satellite Program (DMSP)

This is a relatively new satellite system designed and used by the Air Force. Recently its use has been adapted to the Navy's need at selected stations that are assigned the AN/TMQ-29 or AN/SMQ-10 equipment for tracking. The satellite provides high resolution data comparable to VHRR output along with the capability of both stored and direct readouts. The equipment used with the readout system is unclassified; however, certain aspects of the spacecraft payload system, and orbital operations remain classified SECRET.

GROUND EQUIPMENT

Although several types of ground tracking equipment may be encountered, such as the older models AN/GKR-4 and AN/GKR-7, only the more commonly used AN/SMQ-6(V) and the newer AN/TMQ-29 and AN/SMQ-10 tracking sets are discussed in the following paragraphs.

SATELLITE TRACKING SET AN/SMQ-6(V)

The Meteorological Data Receiver Recorder Set AN/SMQ-6(V) is the ground equipment used by most NAVOCEANMET units that receive and reproduce signals from weather satellites. This system is capable of receiving APT, SR, and land-line transmissions.

Description of Equipment

The AN/SMQ-6(V) ground station equipment consists basically of an antenna system, a receiver, a tape recorder, and a facsimile recorder. The variable (V) equipment portion of the system is the antenna, and the power and distribution control. The main components of each set are pointed out in figure 6-8 and 6-9. Shipboard installations utilize a steerable antenna system with a programmed mode of operation to automatically track the satellite, and a power and distribution control.

Shorebased installations utilize a conical spiral omnidirectional antenna, and a power and distribution control. The receiver is an FM receiver designed primarily for APT satellite reception. The receiver is equipped with both an aural and visual means of detecting signal presence. The tape recorder is utilized to provide storage capability and for playback to obtain additional pictures. The facsimile recorder reproduces the satellite data line by line on a wet electrolytic paper producing a sepia printout.

There are two configurations of the receiver recorder set. The configuration shown in figure 6-8 has a steerable antenna that is directed toward the satellite automatically (PROGRAM Mode) or manually (MANUAL Mode) through the antenna control located in the console. This directional feature enhances reception in high RF environments. The configuration shown in figure 6-9 has an omnidirectional antenna that eliminates the need for the antenna control. In general, the set with the steerable antenna is used on ships because of interference due to high RF electromagnetic radiation. The set with the omnidirectional antenna is used at any tracking station where RF interference is at a minimum.

Purpose of the Equipment

The receiver recorder set provides three modes of operation, APT (Automatic Picture Transmission), DRIR (Direct Readout Infrared), and MAP (recording of weather maps and charts). The purpose of each mode is described in the paragraphs that follow:

1. APT Mode. In the APT mode, the receiver recorder set receives, tape records, and facsimile reproduces cloud and land imagery that is sensed by the SR in the visible region of the spectrum and then transmitted from the satellite.

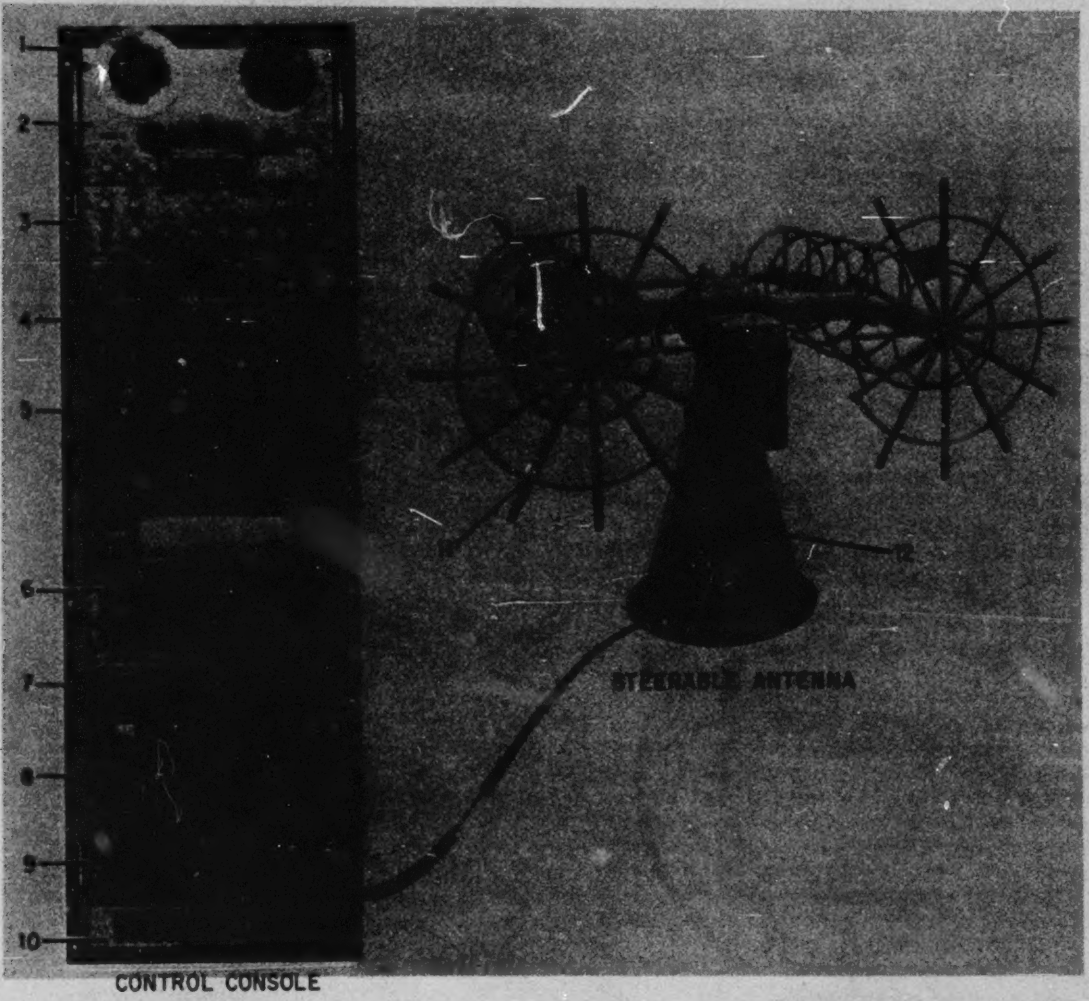
2. DRIR Mode. In the DRIR mode, the receiver recorder set receives, tape records, and facsimile reproduces cloud and land imagery that is sensed by the SR in the infrared region of the spectrum and then transmitted from the satellite.

3. MAP Mode. In the MAP mode, the facsimile recorder components of the receiver recorder set are used to receive and reproduce wire (landline) transmissions of weather maps and charts.

Another purpose to which the receiver recorder set may be used is weather facsimile (WEFAX). WEFAX transmissions however, are not received directly from the satellite that transmitted the original pictures. The original pictures are transmitted to certain ground stations which then select and relay the pictures to various geostationary satellites that are in orbit for retransmission to the APT receiving stations, thereby enlarging the area of coverage available to the APT system because of the higher altitudes at which the geostationary satellites are orbiting.

Operation of Various Components

Descriptions of the various components and specific operating instructions are given in Technical Manual Operation and Maintenance Instructions, Receiver Recorder Set Meteorological Data AN/SMQ-6(V), NA 50-30SMQ6-1. The procedures for setting positions on the control panels, prior to applying power to the equipment, must be carefully followed. (For the GKR-4 and the GKR-7, refer to the appropriate



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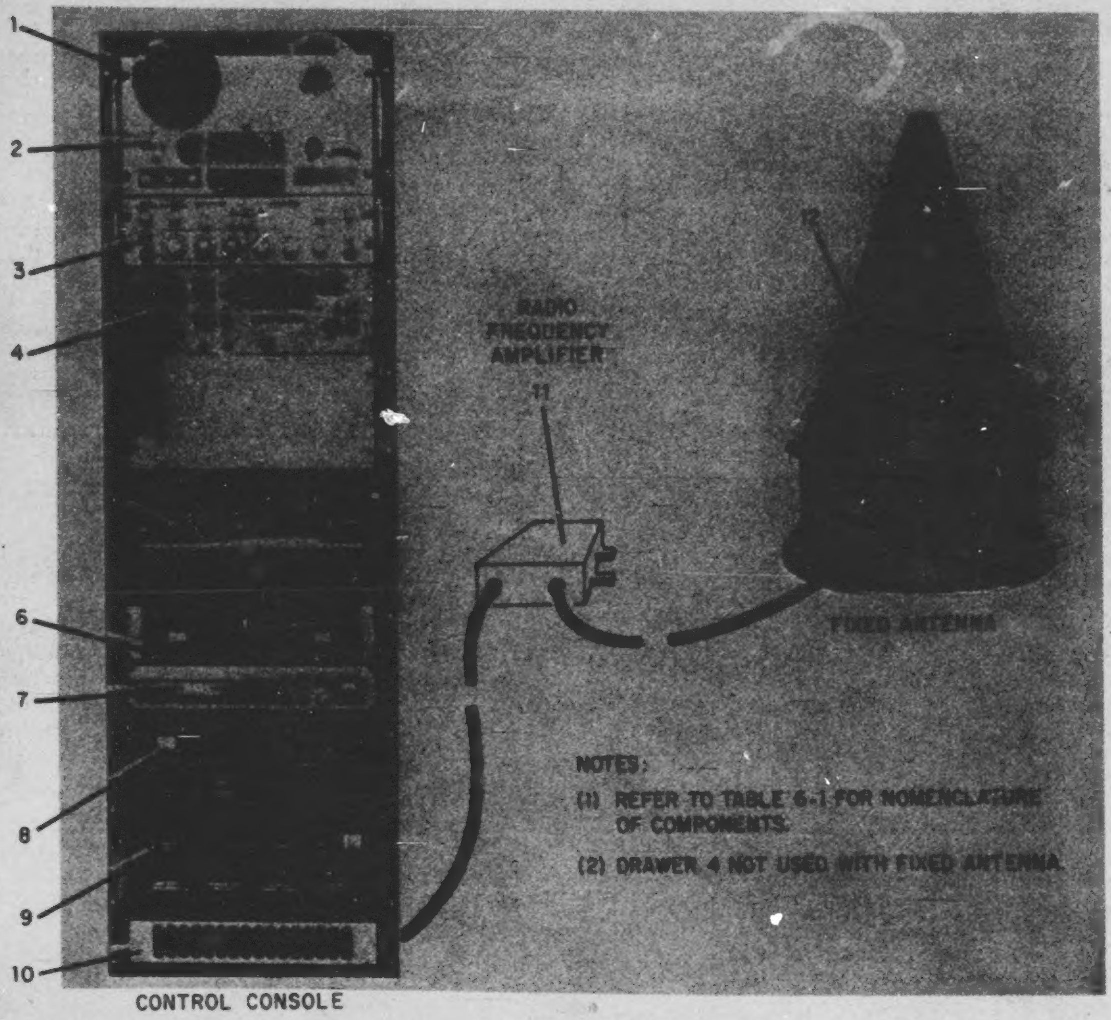
1. Electrical Equipment Cabinet CY-6430/SMQ-6(V)
2. Magnetic Tape Transport RO-351/SMQ-6(V) . . . (DRAWER 1)
   Power Supply PP-6003/SMQ-6(V) . . . (Located behind DRAWER 1)
3. Amplifier Oscillator AM-4969/SMQ-6(V) . . . (DRAWER 2)
4. Power and Distribution Control C-8304/SMQ-6(V) . . . (DRAWER 3)
5. Antenna Control C-7632/SMQ-6(V) . . . (DRAWER 4)
6. Facsimile Weather Data Recorder RO-350/SMQ-6(V) . . . (DRAWER 5)
7. Radio Receiver R-1535/SMQ-6(V) . . . (DRAWER 6)
8. Facsimile Recorder Control C-7630/SMQ-6(V) . . .
9. Facsimile Recorder Demodulator MD-772/SMQ-6(V) . . . (DRAWER 8)
10. Centrifugal Fan HD-801/SMQ-6(V)
11. Dual Array Helix Antenna AS-2192/SMQ 6(V)
12. Antenna Pedestal AB-1080/SMQ-6(V)

Figure 6-8.—Meteorological Data Receiver Recorder Set AN/SMQ-6(V) (with steerable antenna).



NOTES:
(1) REFER TO TABLE 6-1 FOR NOMENCLATURE OF COMPONENTS.
(2) DRAWER 4 NOT USED WITH FIXED ANTENNA.

209.426

1. Electrical Equipment Cabinet CY-6430/SMQ-6(V)
2. Magnetic Tape Transport RO-351/SMQ-6(V) . . . (DRAWER 1)
   Power Supply PP-6003/SMQ-6(V) . . . (Located behind DRAWER 1)
3. Amplifier Oscillator AM-4969/SMQ-6(V) . . . (DRAWER 2)
4. Power and Distribution Control C-7631/SMQ-6(V) . . . (DRAWER 3)
5. Antenna Control C-7632/SMQ-6(V) . . . (DRAWER 4)
6. Facsimile Weather Data Recorder RO-350/SMQ-6(V) . . . (DRAWER 5)
7. Radio Receiver R-1535/SMQ-6(V) . . . (DRAWER 6)
8. Facsimile Recorder Control C-7630/SMQ-6(V) . . .
9. Facsimile Recorder Demodulator MD-772/SMQ-6(V) . . . (DRAWER 8)
10. Centrifugal Fan HD-801/SMQ-6(V)
11. Radio Frequency Amplifier AM-4970/SMQ-6(V) . . . (Located in pedestal when steerable antenna is used.)
12. Fixed Conical Omnidirectional Antenna AS-2191/SMQ-6(V)

Figure 6-9.—Meteorological Data Receiver Recorder Set AN/SMQ-6(V) (with omnidirectional antenna).

technical manuals.) After all controls are properly set, the operator places the complete system in a standby condition. At 12 minutes before zenith time, the operator places the antenna system in the PROGRAM mode of operation. The antenna begins to track the satellite automatically. The received signal automatically turns on the tape recorder and the facsimile recorder. NOTE: Although the antenna system is energized (turned on) 12 minutes before zenith time, the system will not start to operate until the subcarrier signal from the satellite is received. The subcarrier signal activates the automatic start circuit which, in turn, energizes the tape and facsimile recorders automatically.

At the beginning of transmission, the operator uses meters provided with the equipment to monitor the signal applied to the tape recorder, and makes minor adjustments if necessary. Minor adjustments are also made, if necessary, to change the printing density on the paper output of the facsimile recorder.

At the end of a satellite pass, the equipment continues to operate for about 10 to 30 seconds, and then turns off automatically. If an additional set of pictures is required, the tape is rewound, the recorder is placed in the PLAY mode of operation, and the output is fed to the facsimile recorder. At the end of operation, all controls are turned to their nonoperating positions.

Maintenance

Most maintenance will be performed by the Electronic Technicians, however, some maintenance procedures can be performed by the operator. These are contained in table 6-1.

For more detailed information on data pertaining to the maintenance and operation of this equipment, refer to NAVAIR 50-30SMQ6-1, Operations and Maintenance Instructions Manual, Receiver Recorder Set Meteorological Data AN/SMQ-6(V).

AN/TMQ-29 NAVY TRANSPORTABLE TERMINAL AND AN/SMQ-10 SHIPBOARD READOUT EQUIPMENT

These are greatly advanced and uniquely designed systems that receive high resolution satellite picture data from the DMSP polar orbiting weather satellites. The systems can process and develop satellite pictures within

Table 6-1.—Maintenance Schedule.

Frequency	Maintenance
Daily, before the first satellite pass	Clean tape transport.
	Demagnetize tape transport head.
Daily, after each satellite pass	Clean facsimile recorder head.
Weekly	Clean blower filter.
	Clean antenna.
After 500 hours of operating time	Replace the facsimile recorder helix wire.
	Replace the facsimile recorder helix strip.
After 1000 hours of operating time	Replace the facsimile recorder loop electrode blade.
After 6 months	Clean the facsimile recorder tray.

five minutes after receiving data from any of the presently orbiting DMSP satellites.

As both systems are similar in basic design, only the installation is different, discussion will be basically confined to the AN/TMQ-29 or shore type van. If more information is needed, refer to the Operating and Service Instructions Manual, NAVAIR 50-30TMQ29-1.

Equipment Description

The Navy Transportable Terminal AN/TMQ-29 is a semi-trailer equipment van, (fig. 6-10). The van is equipped for towing. An S-Band antenna assembly consisting of a ten-foot reflector and feed assembly are mounted on the top rear of the van. The whole unit is designed for compact transportation. The antenna can be disassembled and stored in designated areas in the van, while the pedestal is stowed on a special carrying rack attached to the rear of the van. The van can be towed over land by truck/tractor or it can be airlifted by a C5A, C141, or equivalent aircraft.

The equipment room (fig. 6-11) contains the electrical racks, and the operating control stations and work areas for maintenance and administrative duties.

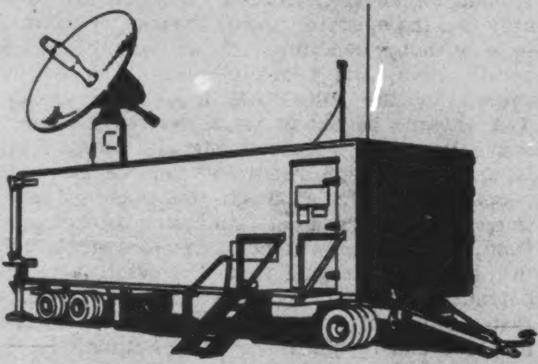


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Figure 6-10.—Navy Transportable Terminal AN/TMQ-29.

The shipboard version, AN/SMQ-10, has two antennas. They are normally mounted one each on the port and starboard sides of the ship just below the flight deck aft. The electronics associated with the antenna are located immediately adjacent to each antenna. The receiving-terminal equipment is located in another space in the ship.

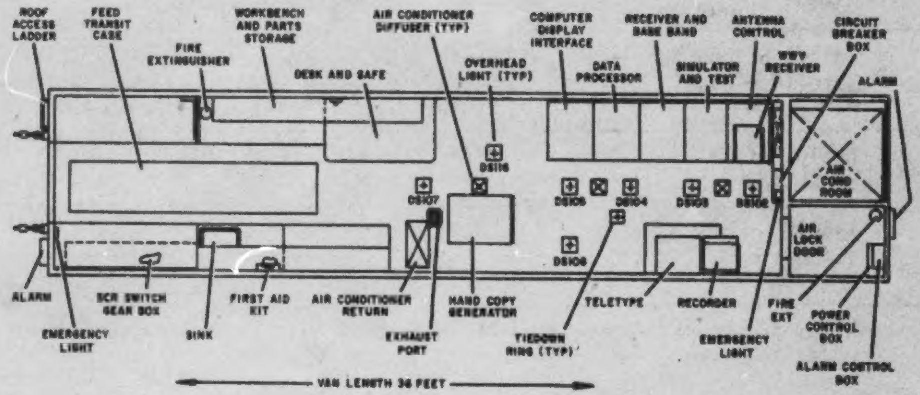
ROOF ACCESS LADDER
FEED TRANSIT CASE
FIRE EXTINGUISHER
WORKBENCH AND PARTS STORAGE
DESK AND SAFE
AIR CONDITIONER DIFFUSER (TYP)
OVERHEAD LIGHT (TYP)
COMPUTER DISPLAY INTERFACE
DATA PROCESSOR
RECEIVER AND BASE BAND
SIMULATOR AND TEST
ANTENNA CONTROL
WWV RECEIVER
CIRCUIT BREAKER BOX
ALARM
AIR COND ROOM
AIR LOCK DOOR
DS116
DS107
DS105
DS104
DS103
DS102
DS106
ALARM
EMERGENCY LIGHT
SCR SWITCH GEAR BOX
SINK
FIRST AID KIT
AIR CONDITIONER RETURN
EXHAUST PORT
HAND COPY GENERATOR
TIEDOWN RING (TYP)
TELETYPE
RECORDER
EMERGENCY LIGHT
FIRE EXT
POWER CONTROL BOX
ALARM CONTROL BOX
VAN LENGTH 36 FEET

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Figure 6-11.—Navy Transportable Terminal AN/TMQ-29 interior layout diagram.

Operation and Maintenance of Equipment

This equipment is operated and maintained by specially trained Electronics Technicians and Data Systems Technicians. Aerographer's Mates do not operate the equipment but work very closely with the technicians in the different aspects of the satellite data presentation. These Aerographer's Mates also receive special training.

RECORDER-WEATHER DATA FACSIMILE RO-402/UMH

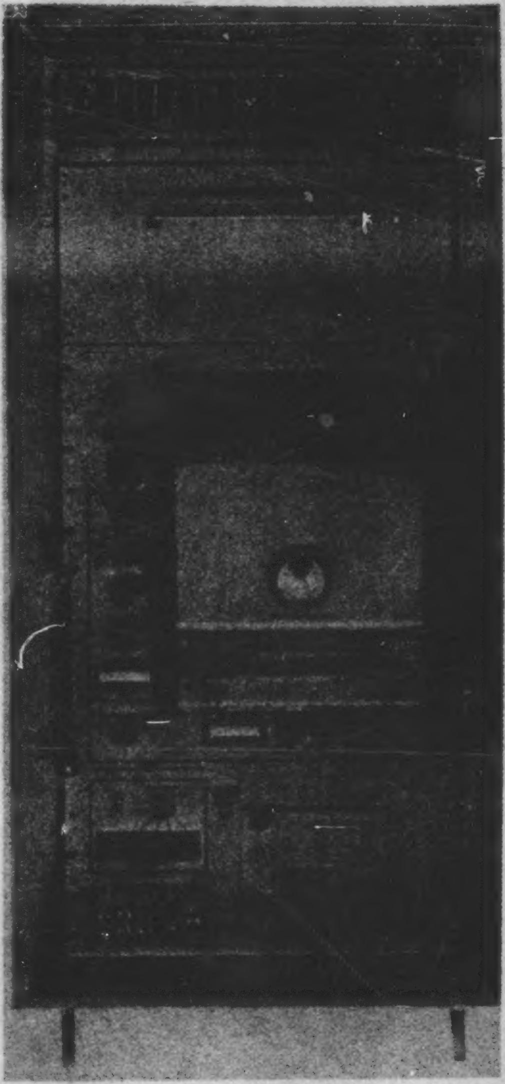
The purpose of facsimile recorder RO-402/UMH is to reproduce meteorological information transmitted from satellite-borne weather sensors. The transmitted information may be recorded directly from a weather satellite receiving station or from a magnetic tape. Provisions have been made to connect to land-line circuits when necessary. The recorder may be operated as a remote unit such as the Recorder Group 0A-8726/UMH (figure 6-12), or used in conjunction with the Receiver Recorder Set, AN/SMQ-6A(V). (See figure 6-13.) For more detailed information refer to Operation and Maintenance Instructions Manual, NAVAIR 50-30RO-1.

RECORDER TEST SET TS3011/GMM

The test set is used for alignment and maintenance of the various facsimile recorders. The test set provides the necessary signals to check the starting, phasing, video (shades of gray and resolution), AGC, and stopping functions of the recorder. For more detailed information refer to NAVAIR 17-15B-50.

MECHANICAL SATELLITE TRACKING EQUIPMENT

Valuable meteorological information is received from the Automatic Picture Transmission (APT) System contained on meteorological satellites. Before this data can be received, a directional antenna must be directed at the satellite so as to acquire the maximum possible signal strength with a minimum of noise. The procedure used to keep the antenna pointed at the satellite is referred to as "tracking."



209.429

Figure 6-12.—Recorder, Weather Data, Facsimile, RO-402/UMH shown in Recorder Group OA-8726/UMH.

In order to perform the task of determining those orbits where acquisition of data is possible and computing the necessary "tracking" data, mechanical equipment and information are necessary. These include the plotting board,

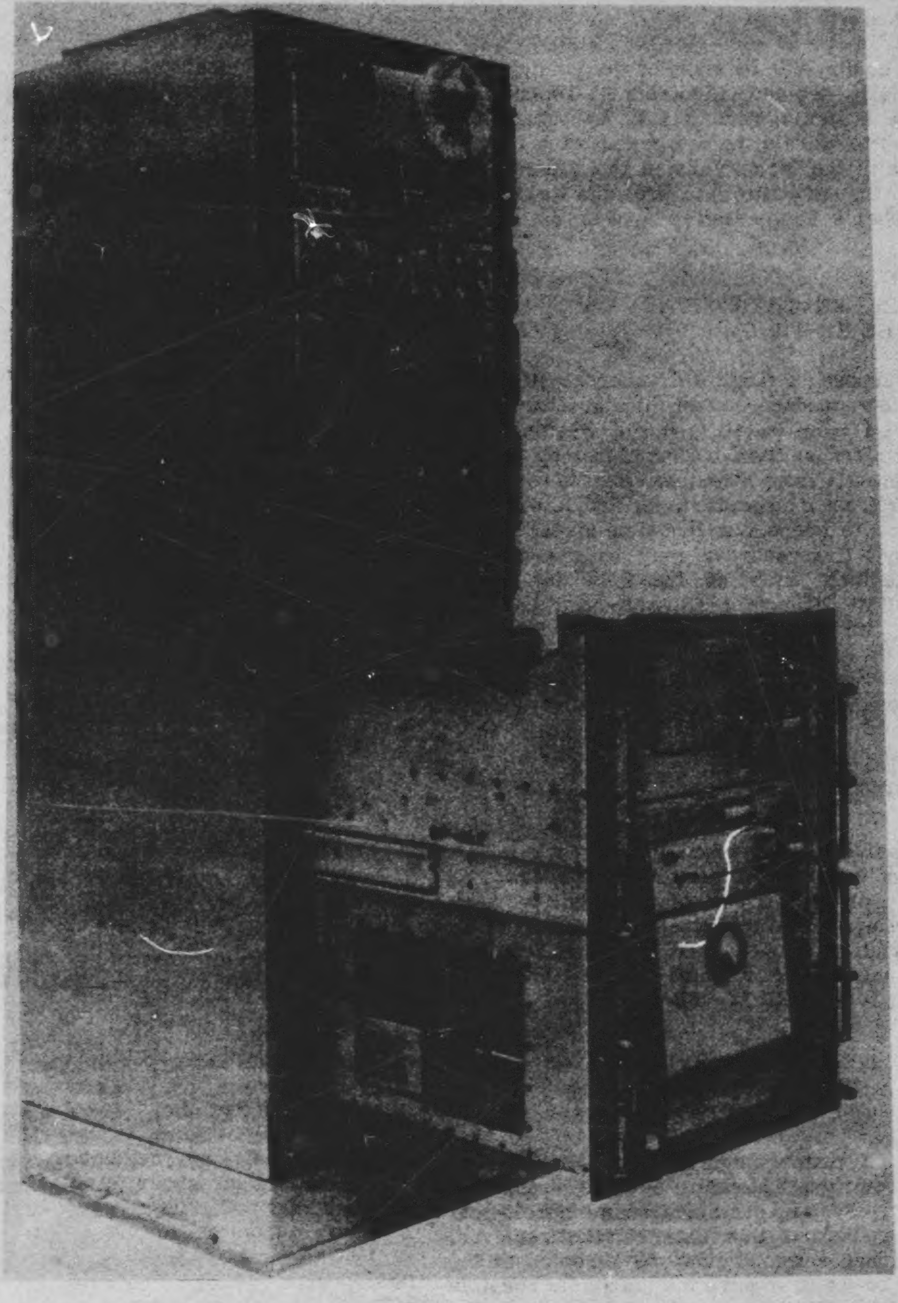


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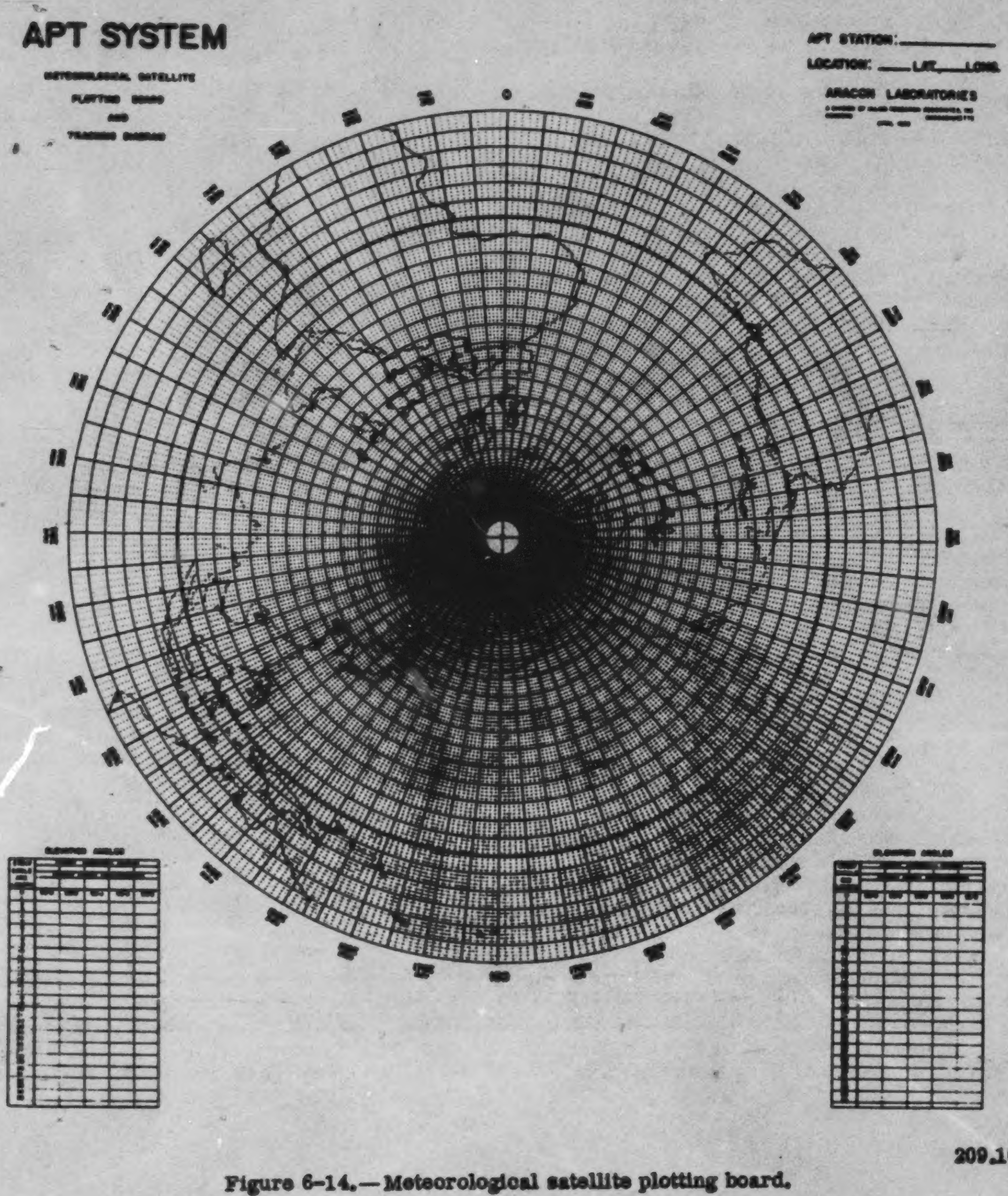
Figure 6-13.—RO-402/UMH Recorder Installed in the AN/SMQ-6(V).


APT SYSTEM
METEOROLOGICAL SATELLITE
PLOTTING BOARD
AND
TRACKING DIAGRAM
APT STATION:
LOCATION: LAT. LONG.
ARACON LABORATORIES
0
ELEVATION ANGLES
ELEVATION ANGLES

209.102

Figure 6-14.—Meteorological satellite plotting board.

transparent orbital overlay, tracking diagram, APT ephemeris predict message, and a clock. The correct procedures for utilizing this equipment and the ephemeris predict message are discussed in chapter 10, Satellite Observations.

METEOROLOGICAL SATELLITE PLOTTING BOARD

The APT plotting board is a polar projection diagram of the earth centered at either pole and extending 30 degrees of latitude past the equator into the other hemisphere. The board or diagram has radials from the pole representing one-degree intervals of longitude; each fifth radial is accentuated. Concentric circles on the projection represent latitudes. The equatorial latitude (zero degrees) is represented by a heavier circle for clarity. (See fig. 6-14.)

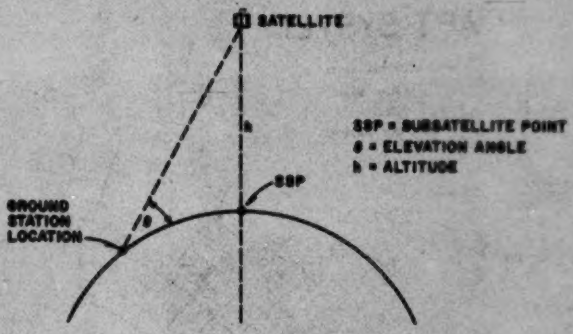
SATELLITE TRACKING DIAGRAM

If the altitude of the satellite and the distance from the APT ground station antenna to the satellite subpoint (the point on the earth directly below the satellite at any given time during its orbit, figure 6-15) are known, then the elevation angle of the satellite may be computed. The tracking diagram (an example is shown as part of figure 6-16) provides a graphical solution of this equation.

The tracking diagram was constructed to show azimuth and distance of the satellite from the APT ground station antenna for a given subpoint position. The concentric curves (near ellipses) are isopleths of great circle arc distance drawn at two-degree intervals.

Azimuth is used directly in tracking. Arc distance must be converted to elevation angle. Tables are provided for this conversion.

NOTE: The arc distances on the diagram may be converted and labeled directly as elevation angles if a circular orbit is achieved (i.e., no change in satellite altitude throughout the orbit). An elliptical orbit will require frequent conversions through use of the tables provided.



209.103

Figure 6-15.—Determining elevation angle of satellite.

A tracking diagram is available for each 5-degree latitude belt. The diagram for the latitude closest to that of the ground station should be used.

TRANSPARENT ORBITAL OVERLAY

The transparent orbital overlay is a clear plastic disk centered at the pole on the plotting board. Notice the subpoint track plotted in figure 6-17. The overlay is not apparent in the figure due to its transparency; however, the subpoint track of the satellite from which data will be acquired is plotted on the overlay rather than the plotting board. This prevents marring the board and allows the plot to be moved as needed.

CLOCK

It is necessary to have a station clock readily available for the purposes of tracking the satellite and determining the times of the pictures. This clock should be accurate to ±1 second and should have an easily read second hand.

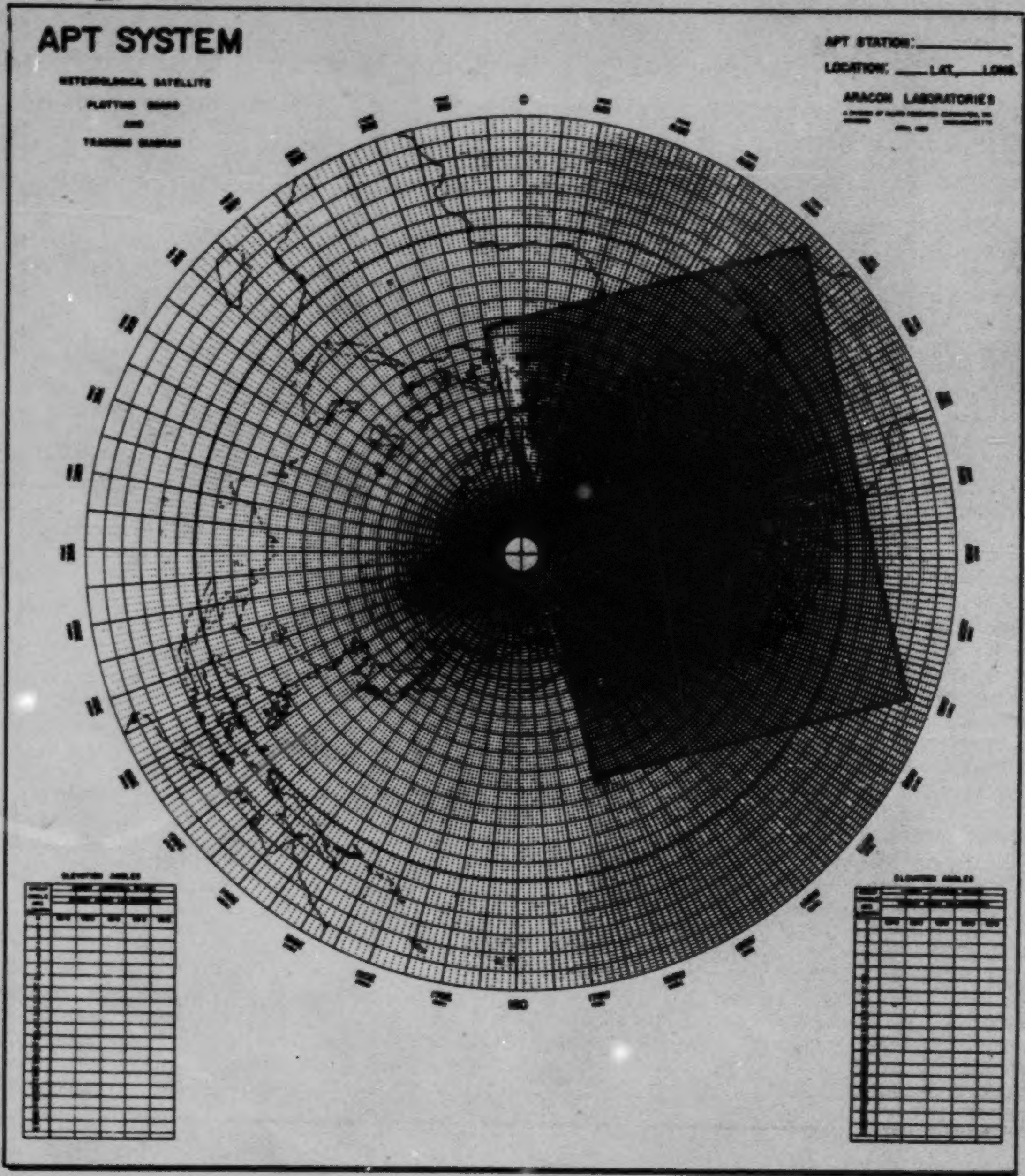

APT SYSTEM
METEOROLOGICAL SATELLITE
PLOTTING BOARD
AND
TRACKING DIAGRAM
APT STATION:
LOCATION: ___ LAT. ___ LONG.
ARACON LABORATORIES
0
180
ELEVATION ANGLES
ELEVATION ANGLES

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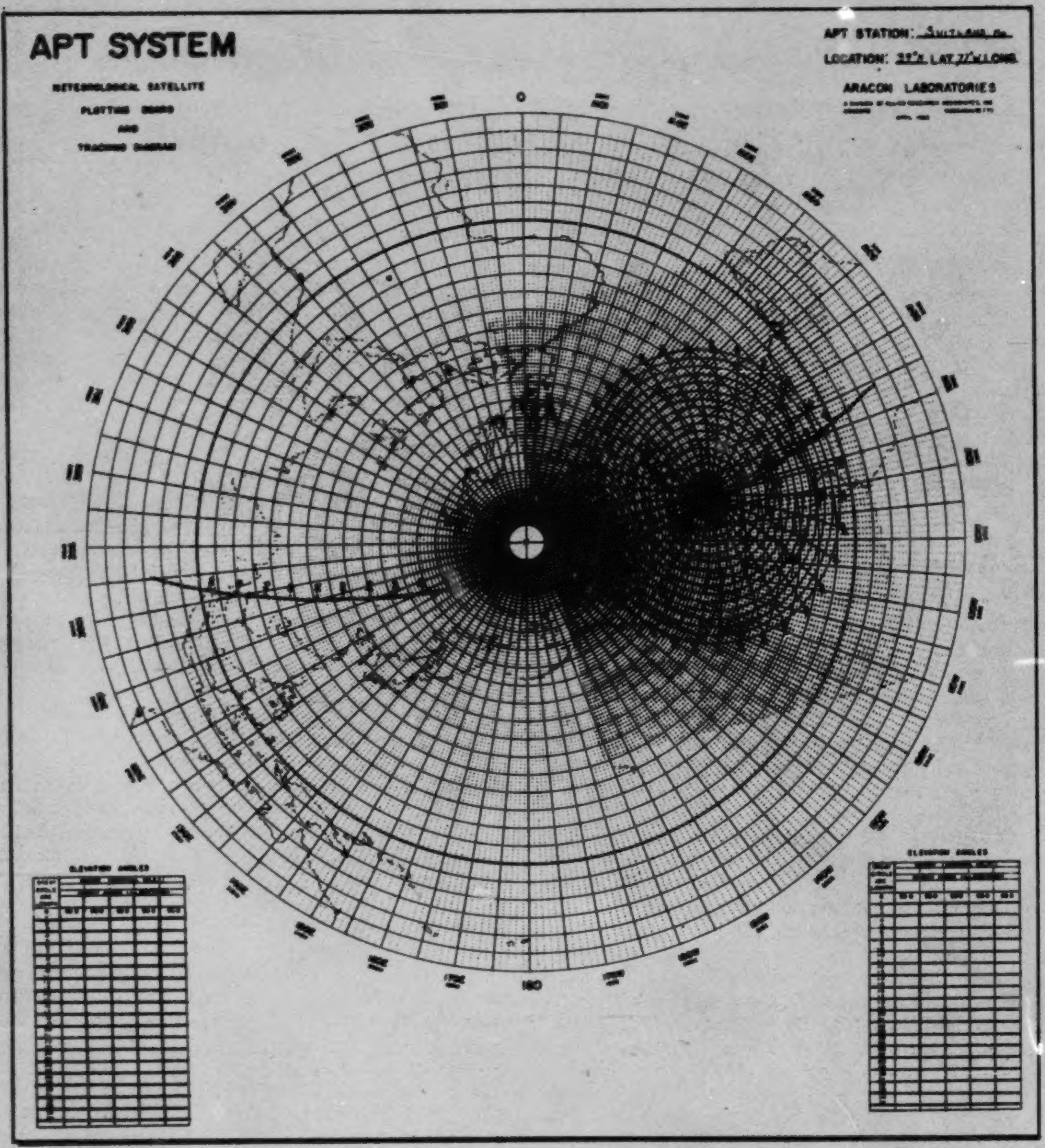
Figure 6-16.—Tracking diagram superimposed on satellite plotting board.


APT SYSTEM
METEOROLOGICAL SATELLITE
PLOTTING BOARD
AND
TRACKING DIAGRAM
APT STATION:
LOCATION: LAT LONG
ARACON LABORATORIES
0
180
ELEVATION ANGLES

209.105

Figure 6-17.—Subpoint track on orbital overlay, plotting board, and tracking diagram.

CHAPTER 7

COMMUNICATIONS EQUIPMENT AND OPERATIONAL PROCEDURES

One of the responsibilities of the Aerographer's Mate reaching greater proportions as time goes by is the transmission and receipt of weather data. Even though every Aerographer's Mate in the Naval Weather Service is not directly connected with weather communications, some time during his naval career he will be responsible for the transmission and receipt of weather data.

It is the purpose in this chapter to present to you as Aerographer's Mates the basic procedures and operation of the weather communications system.

After weather observations have been taken and entered on the appropriate forms, they must be transmitted to other ships and stations. Rapid communication for weather information is imperative for reliable forecasting, as the weather is often a rapidly changing condition. The weather services use two means of transmission: landline and radio.

Landline is a network used for transmitting data directly over fixed wire circuits from station to station or from a control station to a group of stations. The transmission and receipt of printed data over landline circuits are accomplished by the use of teletypewriters. The transmission and receipt of charted data, such as weather maps, over landline circuits are accomplished by the use of facsimile and display equipment.

Radio is used to transmit and receive data where the use of landline circuits is either impracticable or impossible. Radio is the means by which Fleet Weather Centrals, Fleet Weather Facilities, Fleet Numerical Weather Central, National Weather Service, and FAA activities transmit data to ships and overseas land stations, and vice versa. Data are transmitted by radio on predetermined frequencies and at predetermined times.

Printed data are transmitted and received either by radioteletype or by radiotelegraphy. Charted data are transmitted and received by radio facsimile.

TELETYPES

The teletypewriter is little more than an electrically operated typewriter. The prefix "tele" means "at a distance." By operating a keyboard similar to that of a typewriter, signals are produced that cause the teletypewriter to print the selected characters (letters, figures, and symbols). The signals can be sent by radio or landlines to cause the characters to be printed or displayed on other teletype machines.

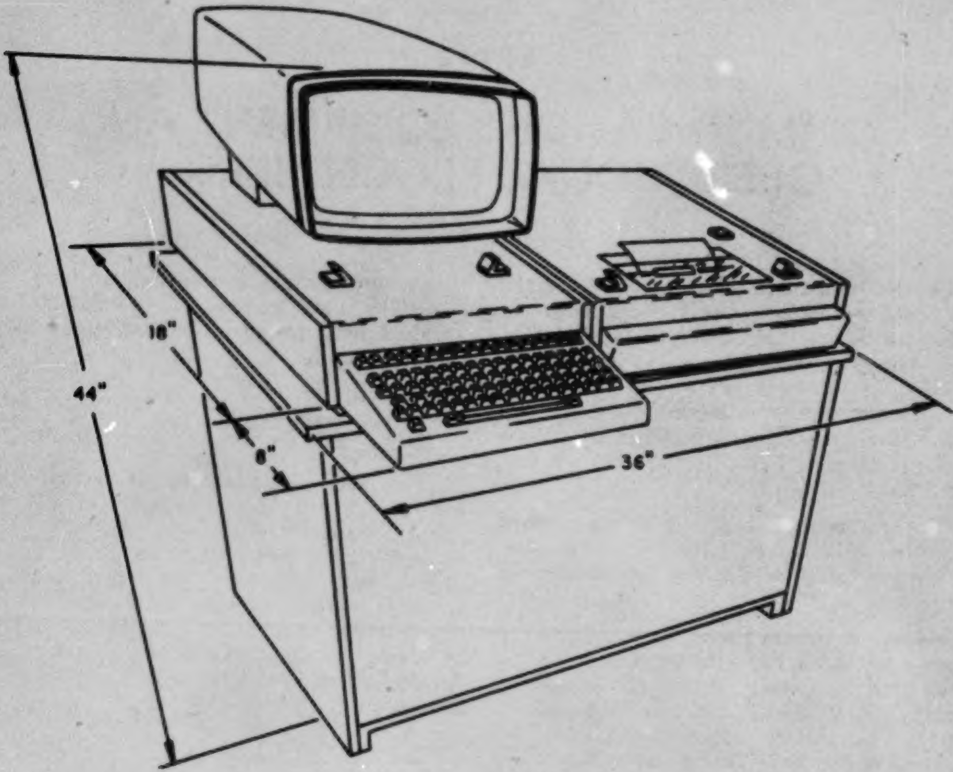
Because of the increasing variety of teletype equipment installed afloat and ashore, it is impractical to describe every piece of equipment you are likely to encounter. The equipment discussed in the ensuing paragraphs is therefore representative of the types commonly employed.

SHORE TYPES

The two types of teletypes normally employed by weather units at shore activities are the Teletype Corp Model 40, used when the weather unit is a contributing station (fig. 7-1), and the Model 28 R/O (receive only), used for receiving data from various FAA and military circuits.

Model 40 Teletypewriter

The Model 40 teletypewriter, provided to all naval weather units contributing to the ADCAD/OWS system, (Airways Data Collection and Dissemination/Operational Weather Support), is used for transmitting and receiving weather data on



209.434

Figure 7-1.—Model 40 Keyboard Visual Display Terminal (KVDT).

the COMEDS weather circuits. This teletypewriter, identified as a KVDT, consists of a keyboard, display, and a printer. The keyboard is similar to the keyboard of a typewriter. The display is a cathode ray tube which displays the characters typed on the keyboard. Special controls permit the operator to change the data displayed. The printer is a 1200 word per minute teletypewriter which prints only incoming data.

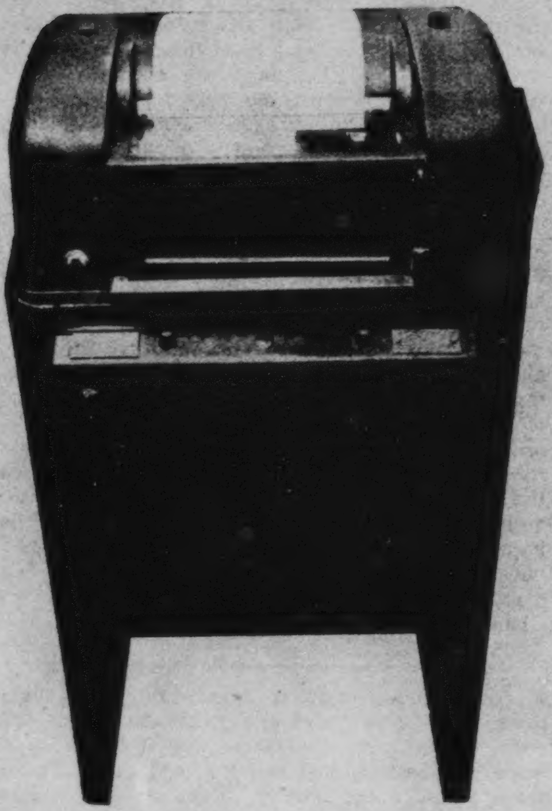
Model 28 R/O

The Model 28 R/O teletypewriter (fig. 7-2) is used for receiving weather data only. It does not normally have a keyboard. The only control keys provided on this machine besides the power switch are the carriage return (CR) key, which provides a means of locally returning the type box to the left-hand margin, and the line feed (LF) key, which provides a means of locally feeding up the paper.

SHIPBOARD TYPES

Most of the teletypewriter sets used by Navy ships belong to the model 28 family of teletypewriter equipments. The model 28 equipments feature light weight, small size, quietness, and high-speed operation. They present relatively few maintenance problems, and are suited particularly for shipboard use under severe conditions of roll, vibration, and shock.

Another feature of the model 28 teletypewriters is their ability to operate at speeds of 60, 75, and 100 words per minute. Conversion from one speed to another is accomplished



209.340
Figure 7-2.—Model 28R/O Teletypewriter.

by changing the driving gears located within the equipment. Most of the Navy's teletypewriters are presently operated at 100 words per minute.

Teletypewriters may be send-receive units or receive units only. They may be designed as floor model, table model, rack mounted, or wall mounted sets.

Model 28 TT-48( )/UG

The model 28 send-receive teletypewriter page printers are basically the same. The TT-48( )/UG is a floor model keyboard-sending and page-receiving teletypewriter (fig. 7-3). The TT-48( )/UG provides a means for exchanging typewritten page messages between two or more ships or stations that are similarly equipped and connected by a radio (or wire) circuit. While transmitting from the keyboard, monitor copy is presented by the typing unit. Hence, messages cannot be transmitted and received simultaneously.

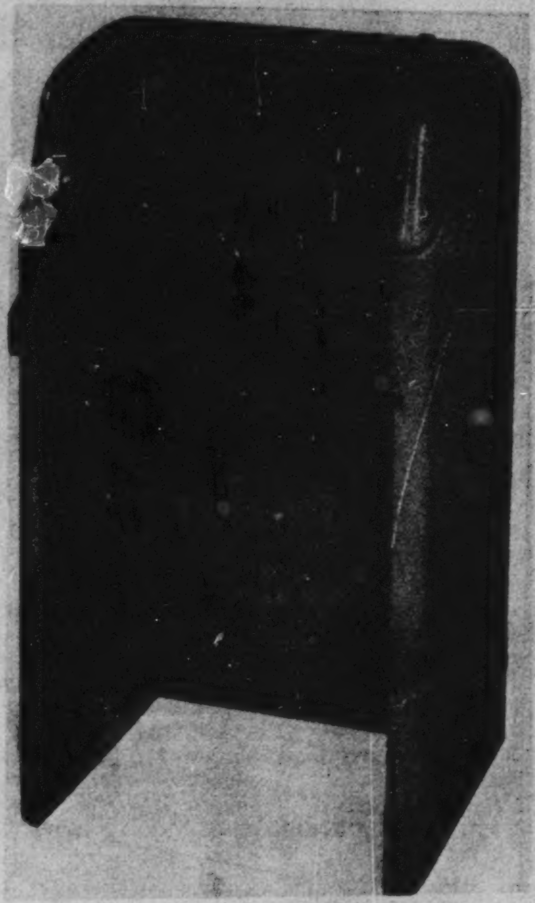


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Figure 7-3.—Model 28 Teletypewriter TT-48 ( ) /UG.

Model 28 TT-69( )/UG

Another example of modification is the TT-69( )/UG (fig. 7-4). Except for being installed

1.217.70
Figure 7-4.—Teletypewriter TT-69 ( ) /UG.

in a cut-down cabinet, the TT-69( )/UG is similar to the TT-48( )/UG. It serves the same purpose and functions in the same manner. Usually, the TT-69( )/UG is installed on small ships where space is of prime consideration. Both the TT-48( )/UG and the TT-69( )/UG models can be installed without the keyboard attached.

TELETYPE SUPPORT AND MAINTENANCE

Teletype maintenance ashore is normally carried out by telephone companies and Western Union. The equipment is inspected and serviced periodically. Aboard ships, however, the teletype repairs and maintenance are handled by the ship's radiomen carrying the appropriate NEC.

Teletype support includes changing the paper, ribbons, and tape as the need arises. The procedures to be followed for these jobs are discussed in the following paragraphs.

Changing Paper

To insert a new roll of paper in the machine, first shut off the power. Press the cover release pushbutton and lift the cover. Push back the paper release lever, lift the paper fingers, and pull the paper from the platen.

Lift the used roll from the machine and remove the spindle from the core of the used roll. Discard the used roll. Insert the spindle in the new roll. Replace the spindle in the spindle grooves with the paper feeding from underneath the roll toward the operator. Feed the paper over the paper-straightener rod, down under the platen, and up between the platen and paper fingers. Pull the paper up a few inches beyond the top of the platen, and straighten it as though straightening paper in a typewriter. Then lower the paper fingers onto the paper and pull the paper release lever forward. While inserting paper, avoid disturbing the ribbon or the type box latch. After the paper is in place, check to see that the ribbon is still properly threaded through the ribbon guides. Also check to make certain that the type box latch has not been disengaged. It should be in a position holding the type box firmly in place. Close the cover. Open the lid by pressing the lid release pushbutton, bring up the end of the paper, and close the lid with the paper feeding out the top of it.

Changing Ribbons

To replace a worn ribbon on the typing unit, press the cover release pushbutton and lift the cover. Lift the ribbon spool locks to a vertical position and remove both spools from the ribbon spool shafts. Remove the ribbon from the ribbon rollers, ribbon reverse levers, and ribbon guides. Unwind and remove the old ribbon from one of the spools. Hook the end of the new ribbon to the hub of the empty spool and wind until the reversing eyelet is on the spool. If the ribbon has no hook at the end, the spool will have a barb that should be used to pierce the ribbon near its end.

Replace the spools on the ribbon spool shafts, making sure they settle on the spool shaft pins and the ribbon feeds from the front of the spools. Turn down the ribbon spool locks to a horizontal position locking the spools in place. Thread the ribbon forward around both ribbon rollers and through the slots in the ribbon levers and ribbon guides. Take up slack by turning the empty spool. After the slack has been taken up, check to make certain the ribbon is still properly threaded through the ribbon guides, and that the reversing eyelet is between the spool and the reverse lever.

Changing Tape

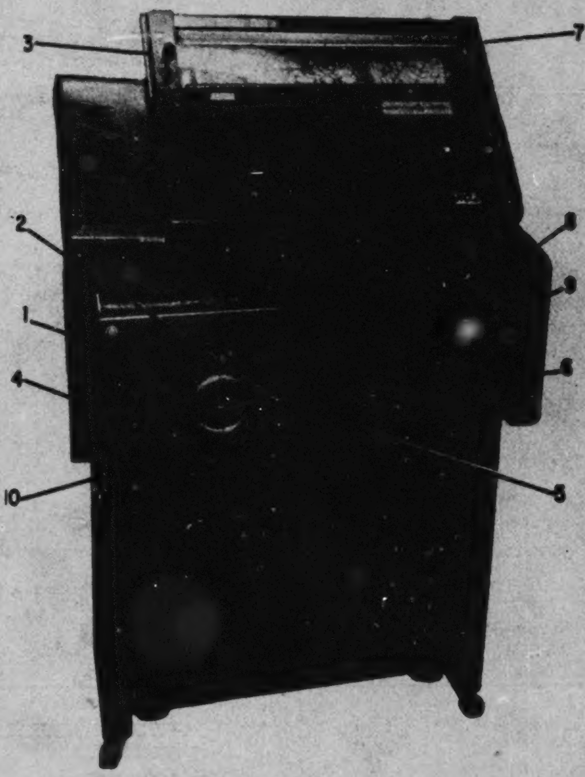
Some models of teletypewriters have the capability of preparing perforated tapes which can store the characters for automatic transmission. Procedures for changing the perforated tape are contained in the operator's instructions of those machines.

FACSIMILE

Many weather offices are equipped with facsimile equipment used to receive and record maps, photographs, or messages. Facsimile equipment is being replaced by Naval Environmental Display Station (NEDS) which is covered in Chapter 9, of this manual. In addition, certain selected stations such as Fleet Weather Centrals, are equipped with special units called transceivers, which transmit as well as record the facsimile messages. Facsimile transmission may be accomplished either by wire (landline) or by radio. In the United States the method of transmission is principally by wire. Stations aboard ship or overseas receive facsimile weather charts by radio on certain designated frequencies of Navy broadcasts or by intercepting other transmitted frequencies contained in the Worldwide Marine Weather Broadcasts manual.

ALDEN FACSIMILE

The Alden Weather Map Receivers are fully automatic, continuous weather map receivers which use the simple electromechanical principle of the Alden recording technique and Alfax electrosensitive paper on which electricity is the ink. The two types in general use today are the Alden Standard All Purpose 19 Recorder (fig. 7-5), and the Alden 18 Auto Select Facsimile Recorder, which is available in the console model and the bench model (fig. 7-6). The paper used in the recorder is white and comes in 170-foot rolls. A crisp sepia map on a clean white background is produced. The paper is thin and suitable for reproduction directly by the Bruning or Diazzo (Ozalid) process. It is packaged in a sealed plastic bag and can be stored indefinitely without dating.



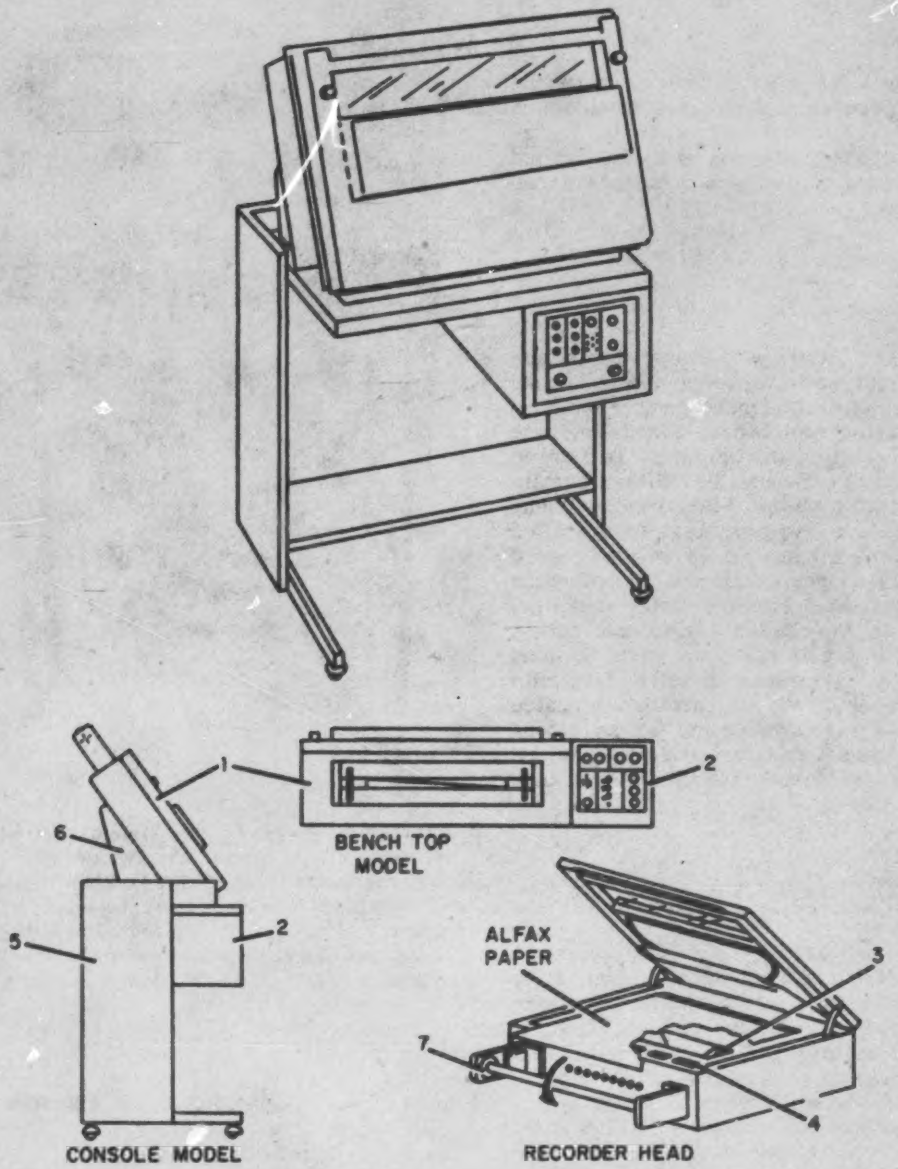
1. Master ac power switch.
2. Automatic fast feed.
3. "No paper" indicator.
4. Program clock.
5. Signal level.
6. White level.
7. Manual fast paper advance.
8. Marking signal test switch.
9. Signal monitor switch.
10. Manual start switch.

209.342

Figure 7-5.—Alden Model 19 Facsimile Recorder.

With the front cover open, the roll of paper is easily snapped into place. After closing, the cover seals the paper in the recorder, preventing moisture loss.

A special feature of the receiver is an easily changed programming clock for automatic chart selection and recording. A change in scan rate


1
2
BENCH TOP MODEL
6
5
2
CONSOLE MODEL
ALFAX PAPER
3
7
4
RECORDER HEAD

209.435

1. Recorder Head.
2. Recorder Control Unit (Electronic Chassis).
3. Helix Drum Assembly.
4. Paper Feed Assembly.
5. Console (Desk) Assembly.
6. Stand Assembly.
7. Paper Take-Up Assembly.

Figure 7-6.—Alden Model 19 Facsimile Recorder.

is easily accomplished by a simple hand operation by station personnel. The recorder is designed to operate on either 60 or 120 scans per minute.

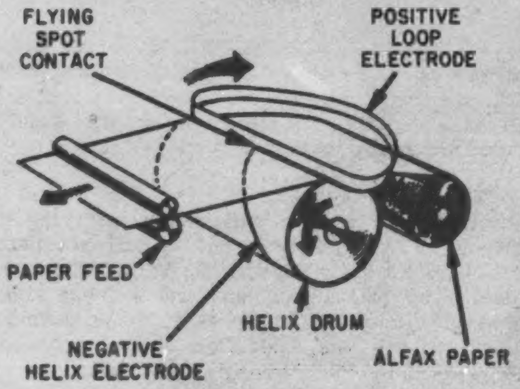
PRINCIPLES OF OPERATION.—The recorder has a helix drum which rotates synchronously with a scanner at the sending point. The paper passes between two electrodes; one is a continuously moving blade in the cover above the paper, and the other is a resilient helix mounting on a rotating drum underneath the paper (fig. 7-7).

As the scanner sees the maps as an ON-OFF signal, it causes current or no current at any instant between the resilient helix and the loop electrode. The resilient helix contacts the loop electrode instantaneously at only one point which is constantly moving from left to right. The paper passes between the helix and the loop. There is an electro-chemical action when current is flowing from the loop to the helix which causes ions to leave the loop electrode and plate the surface of the paper with the markings. This spot, multiplied by ON-OFF pulses, then produces the exact facsimile of the map being transmitted.

OPERATING INSTRUCTIONS.—The operating instructions for the Alden 19 are as follows:

1. Turning Recorder ON-OFF. Turn the recorder ON or OFF using the power switch located on the left-hand side of the cabinet. Trigger the manual start switch to start recording during map signals. Observe the "no paper" indication light; if the light is on, replace the paper. The recorder shuts off at the end of the paper.

2. Setting the Program Clock. Set the start time to occur prior to the first map required. Place the start pin in the inner ring of holes adjacent to the desired start time. Set the stop time to occur during the last required map. Place the stop pin in the outside ring of holes adjacent to the desired stop time. Put the pin in the day dial for the day the recorder is to be OFF.



209.343
Figure 7-7.—Recorder operation of the Alden Facsimile.

3. Marking Amplifier Adjustment. To adjust for best recording, turn the signal level control clockwise from zero to the point where the signal indicator begins flashing; turn the white level control counterclockwise to the point where the lightest map signal is still printing. Once set, the automatic gain control compensates for all normal line level variations. NOTE: If the signal level is set higher than necessary, it reduces map sharpness. The white level overcontrol removes a light signal. Both settings for normal line conditions are 4.

4. Automatic Paper Advance. With the AUTOMATIC FAST FEED switch in the ON position it will advance the paper 6 inches at the end of each map. The MANUAL FAST PAPER ADVANCE switch is located on the upper right-hand side of the recorder case. NOTE: MARKING SIGNAL TEST AND SIGNAL MONITOR switches on the marking amplifier should be to the left when recording. See the operating manual for line level tests.

To change the recorder speed while the recorder is running, proceed as follows:

1. Drum Motor. Set the selector switch to either 60 or 120 rpm.
2. Paper Feed. Press the manual start switch on the auto rephase chassis and hold while pressing the 60 or 120 rpm feed button (upper right side of the recorder head).

To get the best results from this machine, it is imperative the recorder be kept clean and the helix and loop electrode be replaced before they have worn so far that good copy cannot be obtained.

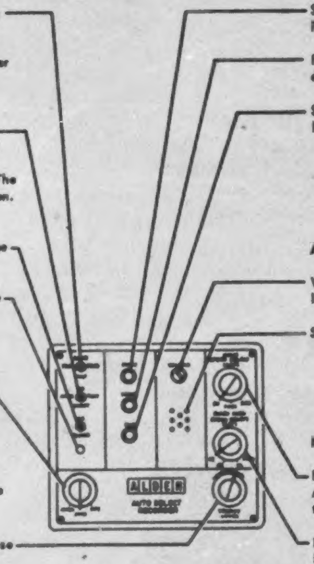
The operating instructions (fig. 7-8) for the Alden 18 are as follows:

1. TURN ON PROCEDURE. The recorder is turned on by turning the POWER switch to the ON position. When the red power ON indicator illuminates, the recorder is in the standby mode and ready to start.

2. SIGNAL LEVEL CHECK. If a signal is absent, the recorder will run by pressing the manual START switch, but it will not print. To check for a signal, turn the VOLUME LEVEL control up (clockwise) and listen for a signal tone of clicks in the speaker. If no sound is heard, check the operation of the equipment by switching the MARK/TEST switch to ON and push the START button. If it marks the paper, this tells you the set is working but no signal is being transmitted. Now return the MARK/TEST switch to the OFF position (center) and push the STOP button.

3. AUTOMATIC CONTROL OF RECORDER. When set for this mode of operation, it will start, phase, printout, and stop automatically from the standard facsimile control signals transmitted over landlines. If fast feed of the paper is required, set the FAST FEED switch to the AUTO position.

4. MANUAL OPERATION. The recorder may be started manually, without the need for a start command, by depressing the START button on the Recorder Control Chassis front panel. Phasing is then accomplished by pressing the PHASE button on the front panel of the recorder. This is done only momentarily, noting the position of the left-hand edge of the recorded map. If not phased, continue this pro-



RECORDER CONTROL CHASSIS

FRONT PANEL. The Recorder Front Panel is divided into five functional sections. The controls for each section are described below.

AUXILIARY/ON-OFF SECTION

FAST FEED Switch: Provides manual fast feed of recording paper from the Recorder when placed in the momentary MAN position. When placed in the AUTO position, the Recorder will "Fast Feed" the ALFAX paper for a preset time on either the automatic or manual STOP command. Center position: AUTO/MAN fast feed is off.

MARK/TEST Switch: When placed in the ON position, the Recorder will print out vertical solid dark bars regardless of input signal applied. The momentary on EVENT position is used to mark the paper when any significant event occurs. The Recorder will print out solid dark copy in the EVENT position. Center position: off.

POWER Switch: Provides power ON/OFF to the Low Voltage Marking Amplifier and Precision AC power supplies.

Power ON Indicator: When lighted, indicates power is ON to Recorder Control Chassis and Recorder Head.

MARKING AMPLIFIER SECTION

MAP-AUTO-APT: Selects MAP or APT operation. The AUTO position provides automatically controlled MAP or APT mode operation in accordance with the transmitted signal from the Scanner. In APT position, the Recorder will not start automatically unless a 1209 Hz tone precedes the 300 Hz start tone. In MAP position, the Recorder will operate from all command tones, but will not go to APT mode of inverted printout.

DENSITY LEVEL Control: Provides marking density increase and decrease adjustment. Results are observed on recorded copy. Should normally be operated 3/4 clockwise position.

COMMAND SECTION

START: When depressed, provides manual starting of the Recorder.

PHASE: When lighted, indicates the phasing cycle. When depressed, provides manual phasing of the Recorder.

STOP: When depressed, provides manual stopping of the Recorder.

AUDIO OUTPUT SECTION

VOLUME Control: Provides adjustment of the audio output level of the incoming signal.

Speaker: Provides aural indication of the incoming signal

MOTOR DRIVE SECTION

HELIX SPEED SELECT (rpm): Selects 120 or 240 rpm. The AUTO position provides automatically controlled speeds from the scanner.

PAPER-FEED SPEED SELECT (lpi): Selects 96, 48, or 45 lines per inch. The AUTO position provides automatically controlled speeds from the scanner.

209.436

Figure 7-8.—Alden Model 18 operating controls and their functions.

cedure until the left-hand edge is in phase. To stop the recorder manually, press the STOP button on the recorder front panel. To manually fast feed the paper, press the FAST FEED switch until the desired amount of paper is fed out, then release the switch.

5. NO PAPER INDICATOR. An indicator lamp on the recorder cover lights whenever the paper supply is depleted or the recorder cover is open and the interlock switch is opened. The set will stop automatically when either of these occur. Either the door must be closed or a new roll of paper installed before the set can be started again.

AN/UXH-2( ) FACSIMILE RECORDER

The AN/UXH-2( ) (fig. 7-9) is used aboard ship and at overseas stations, in conjunction with a radio receiver and a frequency shift converter, for the reception of facsimile weather charts.

The radio receiver's audio output is connected to a converter which changes the signal to electrical impulses. When patched to the latest model, the AN/UXH-2B, these electrical impulses cause a recording across a continuous page of paper by a pressure sensitive technique. This modified method utilizes a conventional helical drum in combination with styluses driven by a heavy, rigid, grooved rubber belt which is both stable and trouble free during its long life. The three styluses press the image on the back of one-time carbon paper. This carbon paper and the plain white paper (rolls of 350 feet each), on which the image finally appears, are fed from separate supply spindles. The paper supply system avoids the slippage and binding common with integrated paper and carbon paper feed techniques during longer periods of unattended operation.

The styluses are spaced on the band so only one stylus is touching the paper at a

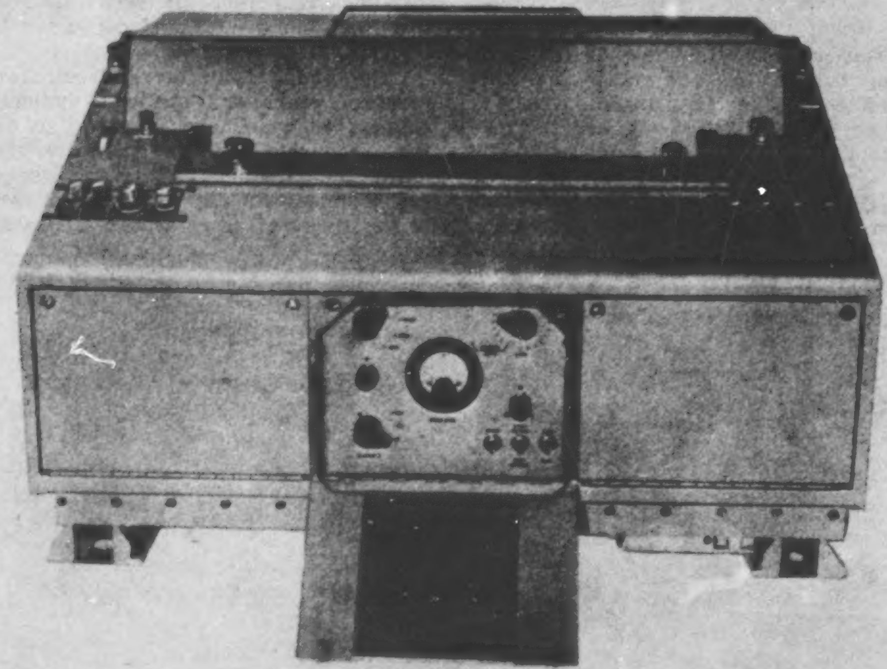


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Figure 7-9.—Facsimile Recorder AN/UXH-2.

given time. The recording speed of this facsimile machine can be set at 60, 90, or 120 scans per minute. The AN/UXH-2 automatically adjusts for the proper recording level phases, records, and stops under control of the received signals. The roll or recorder paper has markings on it to indicate when the roll should be changed; a limit switch stops the recorder when there is about 2 inches of paper left.

With either the frequency carrier shift or the audiofrequency shift methods of transmitting facsimile signals, the output of the radio receiver at the receiving station is an audiofrequency shift signal of constant amplitude. The function of the frequency shift converter CV-172( )/U (fig. 7-10) is to convert the receiver's output to an amplitude-modulated signal that varies between 1200 and 2300 Hz which is the signal required for proper operation of the facsimile recorder.

The CV-172( )/U is not the only frequency shift converter used by the Navy in facsimile installations, but is the one most commonly found aboard ship. The other models you may encounter are models CV-97/UX and the CV-1066/UX. They all perform the same functions.

The AN/UXH-2 Facsimile Recorder is being used aboard naval ships and at selected Naval Weather Service Units primarily as a backup to the Alden facsimile.

RADIO RECEIVERS

Modern Navy radio receivers are easy to operate and maintain. They are capable of receiving several types of signals and can be tuned accurately over a wide range of frequencies. Their size is relatively small when compared to the size of most transmitters because they do not produce or handle large currents and voltages.

R-390A/URR

Operating in the frequency range 500 kHz to 32 MHz, radio receiver R-390A/URR (fig. 7-11) is a continuous tunable, high performance, general purpose receiver for both shipboard and shore station use. It can receive CW, MCW, AM radiotelephone, and frequency shift radioteletype and facsimile signals. It is also an excellent SSB receiver when used in conjunction with single-sideband converter CV-591( )/URR.

The tuning knob turns a complex arrangement of gears and shafts to indicate the frequency, to which the receiver is tuned, on a very accurate counter-type dial. The dial is calibrated in kilohertz, and the frequency reading accuracy of this tuning dial permits use of the receiver as an accurate frequency meter.

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Figure 7-10.—Frequency Shift Converter CV-172 ( ) /U.

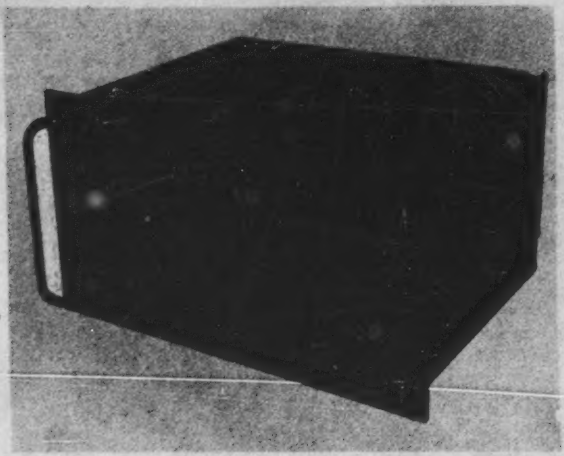

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Figure 7-11.—Radio Receiver R-390A/URR.

R-1051/URR

The R-1051/URR (fig. 7-12) is one of the newest radio receivers. It is a versatile superheterodyne receiver capable of receiving any type of radio signal in the frequency range of 2 to 30 MHz. It can be used as an independent receiver, or, in conjunction with a transmitter, to form a transmitter-receiver combination.

Basically a crystal-controlled equipment, the R-1051/URR employs a digital tuning scheme for automatic tuning to any one of 56,000 operating channels. A display window directly above each control provides a readout of the digits to which the controls are set. The R-1051/URR has 0.5 kHz tuning whereas the R-1051B/URR tunes in 0.1 kHz increments or 2 to 30 MHz with continuous vernier tuning between 1 kHz increments.

This receiver is designated as standard equipment for use aboard all ships.

Receiver Tuning

The operating characteristics of the R-390A/URR Radio Receiver were discussed earlier. The R-390A/URR being a representative receiver will be covered here for receiver tuning.

Haphazard operation or improper setting of receiver controls can result in poor reception. It is important, therefore, to know the function of every control. Although much of the Navy's communication equipment is set up or tuned automatically, an operator must still do a lot to obtain proper performance from the equipment. (Most mechanical or electrical equipment is only good as the person operating it.) Refer to figure 7-13 when studying the following descriptions of switches and controls.

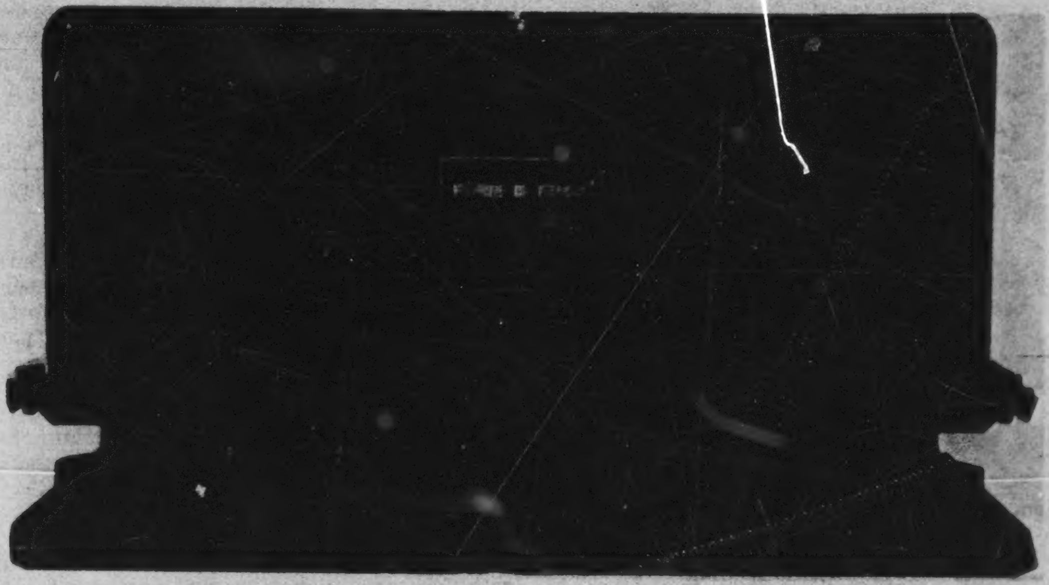
FUNCTION SWITCH.—The function switch serves several purposes. It has a number of positions, each of which is discussed. Its OFF position (self-explanatory) simply turns off power to the receiver.

When the function switch is in the STANDBY position, the tubes are heated to operating temperatures but are not operating. This condition readies the receiver for instant use without a long warmup time.

The abbreviation AGC stands for automatic gain control. Placing the function switch in the AGC position activates the circuitry, which automatically adjusts the RF and IF amplifier gain to compensate for variations in the strength of the incoming signal. In connection with the AGC function, notice that the AGC switch at the top of the panel has three positions marked SLOW, MEDIUM, and FAST. This AGC switch adjusts the rate at which the AGC circuitry responds to a change in the signal strength. The correct position of the AGC switch depends on the type of signal received.

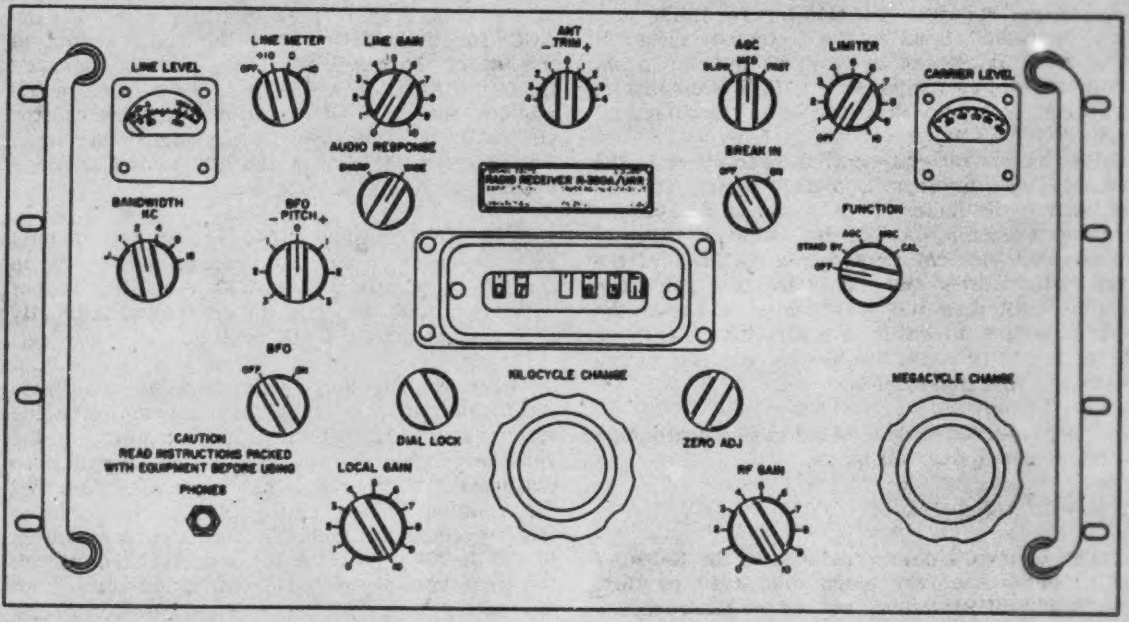
The abbreviation MGC stands for manual gain control. When the function switch is in the MGC position, the AGC circuitry is not activated, and the gain is controlled manually by means of the RF GAIN control.

When the function switch is in the calibrate (CAL) position, a stable crystal oscillator introduces a signal at the imput circuitry of the receiver. This signal allows the operator to calibrate his receiver; that is, to ascertain that the reading of the tuning dial corresponds to the frequency received. The calibration circuitry of the R-390A permits the operator to calibrate the receiver at each 100-kHz point throughout the tuning range of the receiver. In connection with calibration, notice the ZERO ADJ knob near the frequency dial. When turned clockwise, this knob disengages the frequency indicator from the KILOCYCLE CHANGE tuning control.



120.8

Figure 7-12.—Radio Receiver R-1051B/URR.


LINE LEVEL
LINE METER
OFF
+10
0
+20
LINE GAIN
ANT
TRIM
AGC
SLOW
MED
FAST
LIMITER
OFF
CARRIER LEVEL
AUDIO RESPONSE
SHARP
WIDE
RADIO RECEIVER R-390A/URR
BREAK IN
OFF
ON
BANDWIDTH
KC
BFO
PITCH
FUNCTION
STAND BY
AGC
MGC
CAL
OFF
BFO
OFF
ON
KILOCYCLE CHANGE
MEGACYCLE CHANGE
DIAL LOCK
ZERO ADJ
CAUTION
READ INSTRUCTIONS PACKED
WITH EQUIPMENT BEFORE USING
PHONES
LOCAL GAIN
RF GAIN

34.15

Figure 7-13.—Front panel of R-390A/URR.

The calibration procedure consists essentially of the following steps:

1. Tune the receiver to a point where the frequency indicator dial shows an exact multiple of 100 kHz.

2. Turn the ZERO ADJ knob clockwise to disengage the tuning controls from the frequency indicator.

3. With the function switch in the CAL position, turn the KILOCYCLE CHANGE control to give the maximum response to the calibration signal.

4. Turn the ZERO ADJ knob counterclockwise to reengage the tuning control to the frequency indicator.

TUNING CONTROLS.—Two front panel knobs provide the tuning control of the R-390A. They are the MEGACYCLE CHANGE knob and the KILOCYCLE CHANGE knob. The MEGACYCLE CHANGE knob selects any 1-mHz bandwidth of the tuning range. Turning this knob changes the reading of the first two digits of the frequency indicator. The KILOCYCLE CHANGE knob tunes the receiver to any desired frequency within the megahertz band selected by the MEGACYCLE CHANGE control. The last three digits of the frequency indicator dial provide the kilohertz reading. The tuning controls actually adjust the tuning circuits in the RF stages and in the local oscillator in order to select the desired station frequency and to provide simultaneously the desired IF signal to the IF portion of the receiver. The DIAL LOCK knob is associated with the tuning controls. This knob locks the KILOCYCLE CHANGE control so that the frequency setting will not be changed accidentally.

BANDWIDTH CONTROL.—Some transmissions use narrower bandwidths in the RF spectrum than others. Receivers are therefore provided with a control that allows the operator to adjust the pass band of the receiver so only the desired bandwidth is received. On the R-390A receiver, this control is achieved by the BANDWIDTH KC switch. It adjusts the tuned circuits of the IF portion of the receiver, thereby controlling receiver selectivity. Proper adjustment of this control helps to eliminate noise and interfering signals. If the bandwidth is set too narrow, part of the incoming signal will be lost.

BEAT FREQUENCY OSCILLATOR.—Some radio transmissions, such as Morse telegraphy and FSK teletype, contain no audio frequency information when they are received. The R-390A is equipped with a beat frequency oscillator (BFO) to produce an audible output if required. The BFO is activated by the BFO On-Off switch and the pitch of the audio output can be adjusted by the BFO Pitch knob.

GAIN CONTROL.—The R-390A has three front panel gain controls. The RF GAIN control permits manual adjustment of the gain of the RF and IF sections of the receiver. The LOCAL GAIN and LINE GAIN knobs control the gain of the AF circuits. The LOCAL GAIN controls adjust the level of the output to the phone jack. The LINE GAIN controls the level of the audio output used to operate terminal equipment.

ANTENNA TRIMMER.—The front panel control labeled ANT TRIM adjusts the input circuit in such a manner that optimum coupling from the antenna to the receiver can be achieved at each frequency.

AUDIO RESPONSE.—The AUDIO RESPONSE control, which adjusts the bandwidth of the audio circuits, has two settings: SHARP and WIDE. The setting of this control depends on the type of signal received.

LIMITER.—When the control labeled LIMITER is activated, the operator can control the amplitude of the audio output circuits to predetermined limits. The setting of the limiter control depends on the type of signals received. A low setting of the control, for example, would be desirable to prevent loud crashes of static in the output when monitoring voice signals. If the received signal is FSK-modulated, it may be desirable to remove all amplitude variations by using a high setting on the LIMITER control. For many types of reception, however, the LIMITER should not be activated.

BREAK-IN.—The ON-OFF switch labeled BREAK-IN is used when a receiver and transmitter are operated together as a radio set. In the ON position, circuits are activated for removing the antenna from the receiver and for grounding the antenna and receiver audio circuits whenever the transmitter is energized.

INDICATORS.—Three indicators are mounted on the front panel of the R-390A. The frequency indicator dial indicates the frequency to which the receiver is tuned. This dial is of the digital-counter type, which permits frequency to be read directly with little chance of misreading.

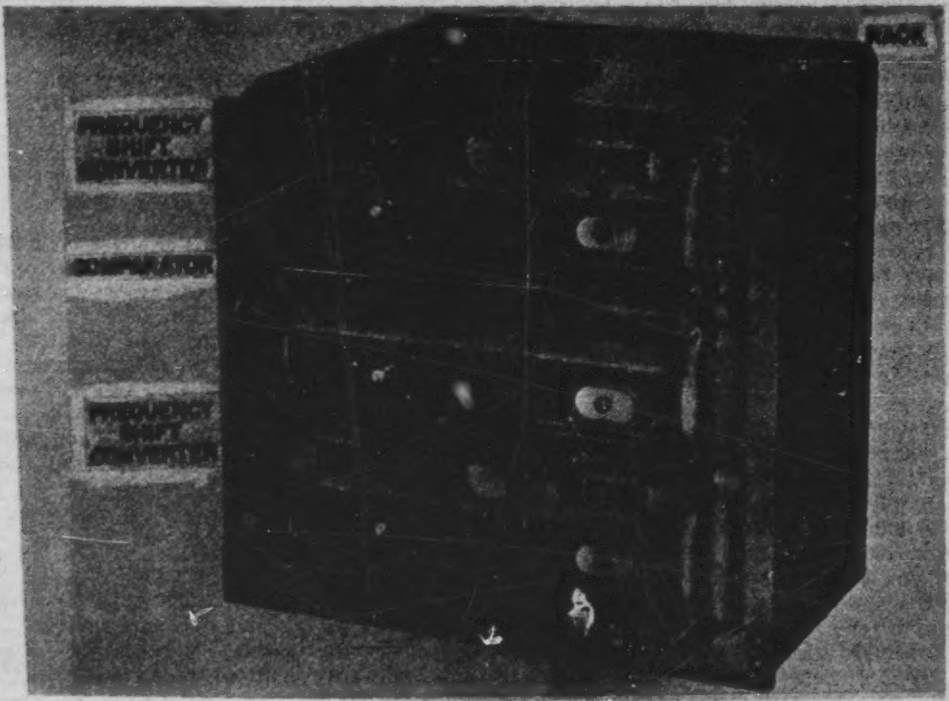
The CARRIER LEVEL indicator—a meter—measures the level of the RF signal appearing at the input of the receiver. The operator will find this meter valuable in tuning to the exact frequency that gives the strongest signal. It is also used to indicate proper adjustment of the antenna trimmer. The indicator labeled LINE LEVEL monitors the level of the line audio output used to drive the terminal equipment. This meter is placed across the output circuit by the LINE METER switch. The three available values of meter sensitivity (voltage required for full-scale deflection) are determined by the setting of the LINE METER switch. This meter is valuable in maintaining the proper output level when making tape recordings.

COMPARATOR-CONVERTER GROUPS AN/URA-8( ) AND AN/URA-17( )

Converters are an integral part of every radioteletype system. In some instances, the keyer is built into the radio transmitter, but the converter is a separate piece of equipment.

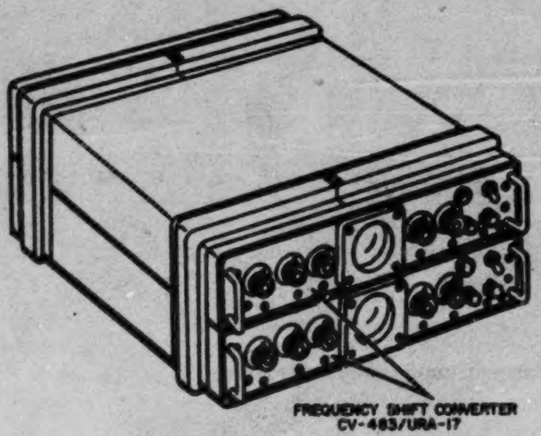
The AN/URA-8( ) and AN/URA-17( ) frequency carrier shift converter-comparator groups (fig. 7-14 and 7-15) are used for diversity reception of Frequency Shifted Radio Teletype signals. They are most commonly used on ship-to-shore or ship-to-ship circuits.

For either space diversity or frequency diversity reception, two standard Navy receivers are employed in conjunction with the converter-comparator group. In space diversity operation, the two receivers are tuned to the same carrier frequency, but their receiving antennas are spaced some distance apart. Because of the required spacing between antennas, space diversity is usually limited to shore



1.235

Figure 7-14.—Converter-Comparator Group AN/URA-8 ( ).



50.76

Figure 7-15.—Converter-Comparator Group AN/URA-17 ( ).

station use. In frequency diversity operation, the two receivers are tuned to different carrier frequencies carrying identical intelligence.

In diversity reception, the audio output of each receiver is connected to its associated frequency shift converter, which converts the frequency shift characters into d.c. pulses. The d.c. (or mark-space) pulses from each converter are fed to the comparator. In the comparator, an automatic circuit compares the pulses and selects the stronger mark and the stronger space pulse for each character. The output of the comparator is patched to the teletypewriter. The converter units can also be used individually with separate teletypewriters to copy two different FSK signals.

The newest converter-comparator group, the AN/URA-17( ), is a completely transistorized equipment designed to perform the same functions as the AN/URA-8( ). Since present procurement of frequency shift converters is confined to the AN/URA-17( ), there are relatively few installations having AN/URA-8( ) converters.

The AN/URA-17( ) consists of two identical converter units; each converter has its own comparator circuitry. Hence, a separate comparator unit is not required. The physical size of the AN/URA-17( ) is further reduced by using transistors and printed circuit boards. The complete equipment is less than half the size of the older AN/URA-8( ).

Proper tuning of the receivers feeding these converters is important. Good communications are often the result of a properly tuned receiver. Each converter has a small oscilloscope mounted in the front which supplies the operator with a visual presentation of the input signal into the converter. Refer to figure 7-16 for examples of how the correct scope presentation should appear when the receiver has been properly tuned.

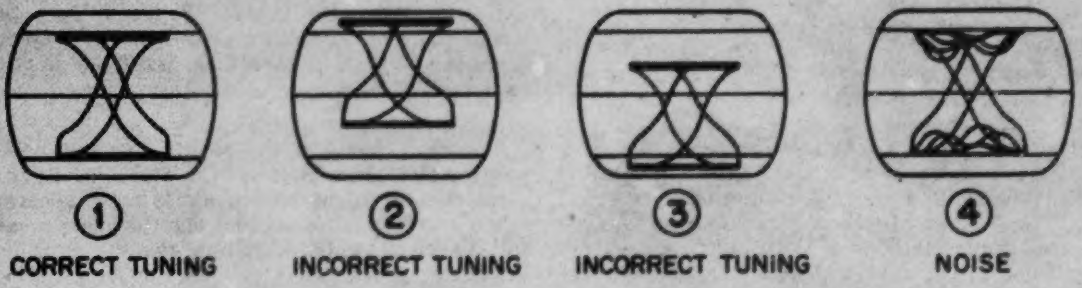
CONUS METEOROLOGICAL DATA SYSTEM

(COMEDS) CIRCUITS

The modern high performance aircraft used in naval operations requires a myriad of nationwide and worldwide weather data to ensure safety and mission completion. To meet these requirements, circuits were being saturated with data. In most cases the data routinely received was only useful to a few weather offices. The COMEDS System, a USAF managed component of the Defense Communications System (DCS), was designed to alleviate overloading of circuits and provide weather offices with the data routinely required for the completion of their mission and assigned tasks.

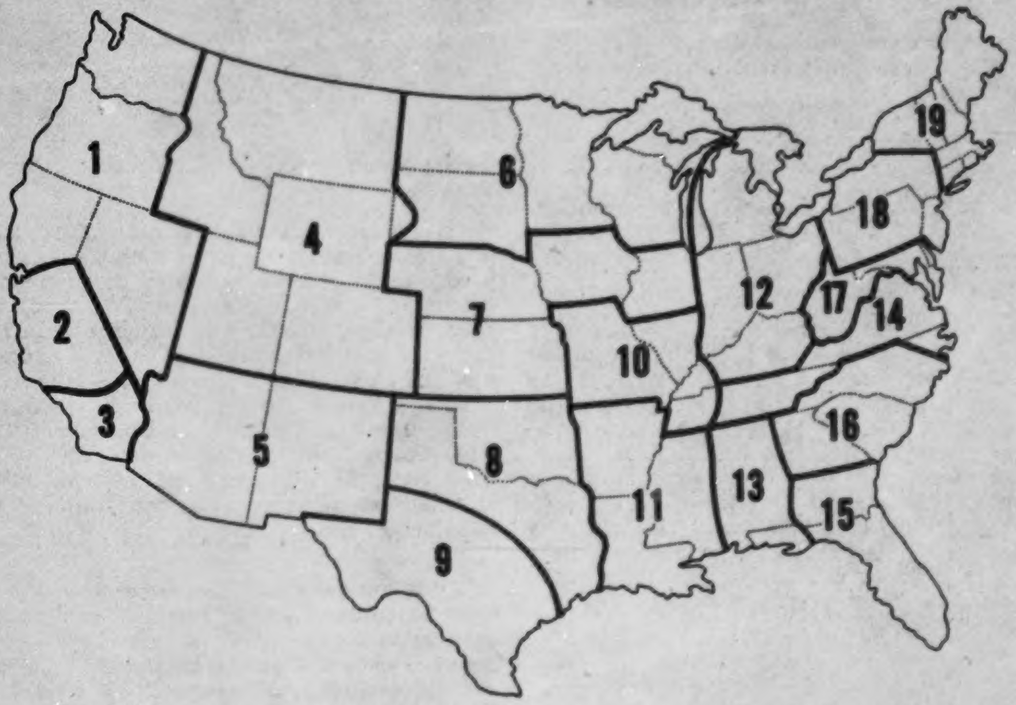
COMEDS consists of nineteen area circuits with 20 to 25 pieces of terminal equipment on each circuit (fig. 7-17). It is a duplex system (receive on one side and transmit on the other side of the circuit) consisting of a 1200 wpm loop circuit. The system is completely controlled by a Univac 1108 computer at the Carswell ADWS. It contains an error detection capability advising you when an error occurs; you receive only that data specifically addressed to you. Transmissions from various stations are controlled by a polling sequence comparable to the old COMET system.

The system is engineered in a way that most data delivered will be individually tailored


①
CORRECT TUNING
②
INCORRECT TUNING
③
INCORRECT TUNING
④
NOISE

209.341

Figure 7-16.—Scope patterns of correct and incorrect tuning on converter oscilloscope.


1
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18
19

209.437

Figure 7-17.—COMEDS circuit areas.

to the stated needs of your office. This is accomplished by use of the Carswell message build capability in conjunction with the selective addressing and printout capability of the system. This selective capability also permits your office to predetermine which data will be delivered to your forecaster and observer printer terminals.

FAA CIRCUITS

The Federal Aviation Administration (FAA) is responsible for establishing, operating, and maintaining communications systems and circuits required for the collection and dissemination of meteorological information utilized by civil aviation. The FAA also provides and operates a communications system for the collection and dissemination of meteorological information required by the National Weather Service. The National Weather Service, which serves the general public, determines the form and content of meteorological information to be scheduled on the FAA fixed weather communications circuits, and the extent of distribution required. The civil weather communications systems serving the various U.S. meteorological agencies are the FAA Weather Teletype Services A, C, and O. In addition, the National Facsimile Network and the High Altitude Facsimile Service are under the control of the National Weather Service.

The Modernized Weather Teletypewriter Communications System (MWTCS) consolidates the circuit control and relay functions of Services A, C, and O into a single Weather Message Switching Center (WMSC) at Kansas City, Missouri. These functions are performed automatically by a group of electronic computers, which are combined to operate as a real-time, store-and-forward communications switch. All Service A and C circuits extend directly into the WMSC. Certain of the Service O circuits also extend directly into the computer switch, while others, from overseas points, pass through the Aeronautical Fixed Telecommunications switch which is collocated and interconnected with the WMSC. Computer-to-computer links provide for the exchange of data between the WMSC and the National Meteorological Center at Suitland, Maryland, and between the WMSC and the USAF Automated Network at Carswell AFB, Texas. For a more complete description of the highly modernized circuitry used in this system, refer to the Federal Aviation Administration Flight Service Manual 7110.10( ) chapter 4.

WEATHERVISION SYSTEMS

A great development in communications-meteorology with which the Aerographer's Mate should be familiar is the weathervision system. This is a closed circuit wire transmission television system for transmitting weather information instantaneously to several remote locations simultaneously. A television camera in the station's weather office transmits weather maps and other meteorological information to receivers placed at various locations on the station. Additional weather briefing information is obtained by pilots via two-way radio communications.

At the present time there are two primary weathervision systems in operation throughout the Naval Weather Service. The first and oldest is the AN/GMQ-19A(V) and the newest is the AN/GMQ-27(V). Both sets are designed as a closed circuit television system and two-way audio system. These two systems are briefly discussed in the following paragraphs.

AN/GMQ-19A(V) AND AN/GMQ-27(V) WEATHERVISIONS

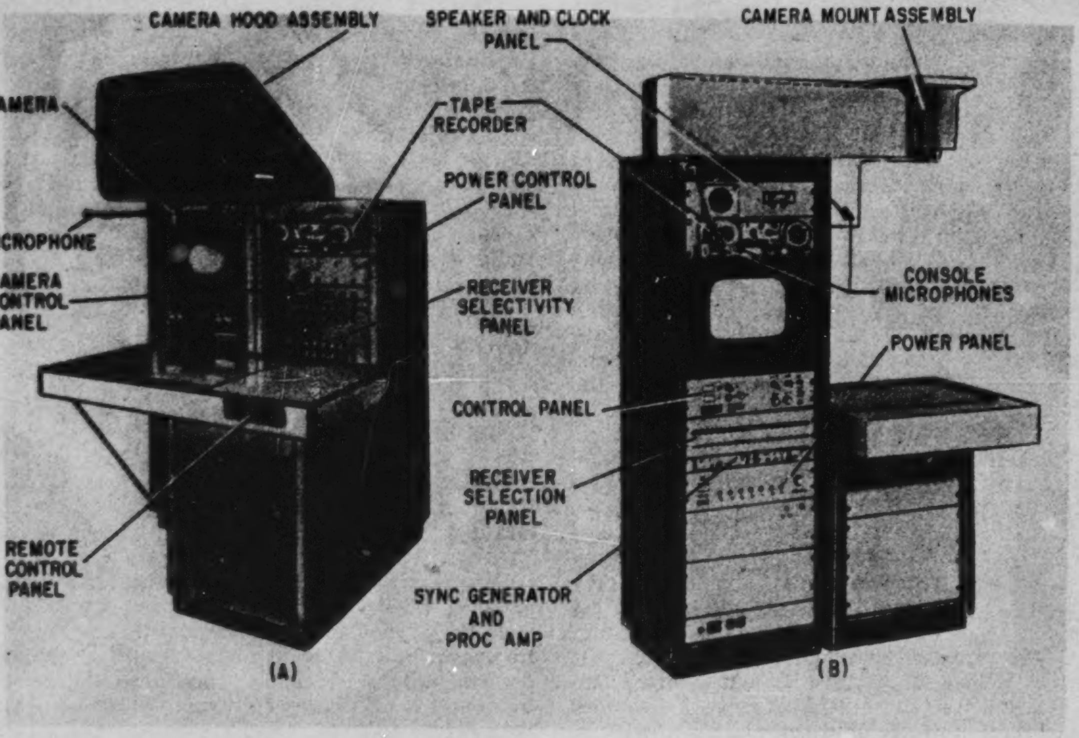
The consoles of the Weather Television System AN/GMQ-19( ) currently in use and its replacement, Weather Television System AN/GMQ-27( ), are illustrated in figures 7-18 (A) and (B).

There are a number of modifications which have been incorporated into the newer AN/GMQ-27. These changes however are primarily improvements in solid state circuitry, camera design, etc. Maintenance procedures performed by contract or station electronic personnel have changed to some degree. The minor preventive maintenance required of the Aerographer's Mate remains relatively unchanged and will be discussed later in this section. The system arrangement and related functions have remained relatively stable.

All components of the central weather station are mounted within or on the metal cabinet assembly. Two rear access doors are provided which are hinged and will lift off. The light table on the right side of the console contains six fluorescent lamps beneath a glass plate and diffusion glass cover. Two 150-watt floodlights are provided for opaque illumination when not using the light table for transparent illumination.

The camera assembly, with its component parts, is mounted rigidly to the top of the cabinet over the light table. A covered housing protects the lens zoom and focus motors.

The recorder is located just above the video screen. It is a single channel, 24 hour, magnetic tape recording and reproducing unit designed to record from either a microphone, a telephone, or a direct line. It will record continuously


CAMERA HOOD ASSEMBLY
SPEAKER AND CLOCK PANEL
CAMERA MOUNT ASSEMBLY
CAMERA
TAPE RECORDER
POWER CONTROL PANEL
MICROPHONE
CAMERA CONTROL PANEL
RECEIVER SELECTIVITY PANEL
CONSOLE MICROPHONES
POWER PANEL
CONTROL PANEL
RECEIVER SELECTION PANEL
REMOTE CONTROL PANEL
SYNC GENERATOR AND PROC AMP
(A)
(B)

210.360

Figure 7-18.—(A) Weather Television System AN/GMQ-19 ( ) console. (B) Weather Television System AN/GMQ-27 ( ) console.

Figure 7-18.—(A) Weather Television System AN/GMQ-19 ( ) console.
(B) Weather Television System AN/GMQ-27 ( ) console.

for 24 hours (plus a 15 minute overtime allowance) without tape change. Cranks are provided on the reel spindles for manually advancing or rewinding the tapes. The tape is motor driven in the forward direction only and must be rewound manually. A portable tape demagnetizer is provided with the unit for degaussing of the magnetic recording tape. The unit will degauss a 2-inch roll of magnetic recording tape in 5 to 10 seconds.

Control panels on the console contain all the necessary switches and controls for operation of the system.

The television monitors used at remote locations consist of a 21-inch television monitor mounted in a metal case assembly. Normal television controls pertaining to contrast, brightness, etc., are provided on the front panel.

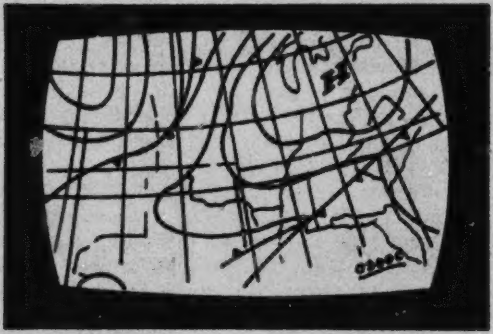
The weather television system should be checked daily for proper operation. Both the video and audio portions should be activated, with checks of reception at remote stations being made. If faulty operation is noted during the daily check, proper maintenance personnel should be notified.

Presentation

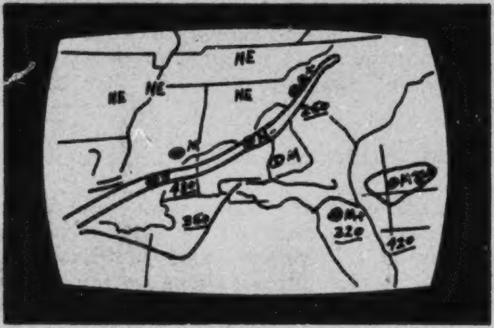
Weathervision systems, at stations where they have been installed have proven to be a valuable tool in the weather briefing situation. Figure 7-19 (A), (B), and (C) shows some of the types of weather data that can be presented on weathervision equipment.

Maintenance

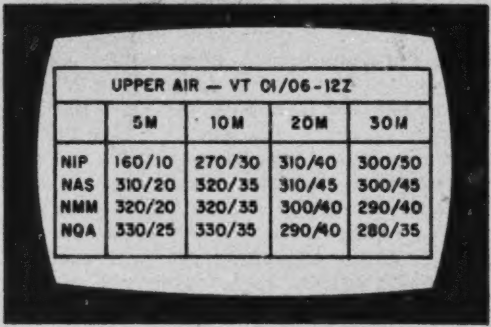
Contract employees or station electronics personnel perform the required electrical and electronic maintenance on weathervision systems. However, there are a number of minor preventive maintenance tasks and inspections



(A) SURFACE WEATHER MAP WITHOUT STATION MODELS



(B) RADAR SUMMARY CHART



UPPER AIR — VT 01/06-12Z

	5M	10M	20M	30M
NIP	160/10	270/30	310/40	300/50
NAS	310/20	320/35	310/45	300/45
NMM	320/20	320/35	300/40	290/40
NOA	330/25	330/35	290/40	280/35

(C) UPPER AIR FORECAST DATA

209.438

Figure 7-19.—Typical weather vision transmissions. (A) Surface weather map; (B) radar summary chart; (C) upper air forecast data.

which may be performed by the Aerographer's Mate. These are limited to the inspections, checking of switches, and cleaning described in the following paragraphs.

CHASSIS ASSEMBLY COMPONENTS.—Under normal conditions, the components of all chassis assemblies should be inspected for dirt, rust, or corrosion on a monthly basis. If the equipment is located under exceptionally hot, humid, or dusty conditions or in the proximity of salt water, these inspections should be conducted weekly.

If cleaning is required, remove grease and oil from the chassis and cabinets using cleaning solvent, Federal Specification P-S-661, or equivalent. To clean painted panels use cleaning compound Military Specification MIL-C-18687, and warm, clean water. Rinse with clean water.

CAUTION: If solvent is used be sure the area is well ventilated. Do not inhale solvent vapors or allow solvent to come in contact with the skin. Keep solvent away from open flame.

TELEVISION VIEWERS.—Under normal conditions, the glass on the front of the television viewers should be cleaned weekly; if other than normal conditions exist, they should be cleaned daily.

If cleaning is required, use a soft cloth soaked in aliphatic naphtha, Federal Specification TT-N-95A. Polish with a clean dry cloth.

CONSOLE LIGHT TABLE.—The plastic cover on the console light table should be cleaned weekly unless required more often due to dusty conditions. Cleaning should be accomplished by washing with a soft cloth and warm, clean water and then polishing with a soft dry cloth.

The lamps in the console light table should be checked daily to ensure they are operating properly.

COMMUNICATION PROCEDURES

COMEDS

A typical weather office has two distinct and relatively independent work areas (forecaster and observer). The COMEDS system was designed on the precept that data must be delivered and messages composed in the appropriate work area.

Most weather offices contributing to the COMEDS system should have a transmit facility and receive capability in each area. This system does away with tape preparation entirely. Messages are formatted and prepared on the keyboard display unit. Using this method, errors in transmitted messages should decrease almost to zero. As the message is typed on the keyboard, it is electrically stored and simultaneously displayed on the display unit. This editing feature permits you to correct such errors by changing discrete characters or by adding or deleting characters as needed without starting the message over. All line signaling is done using the eight-bit American Standard Code for Information Interchange (ASCII). This code makes use of a parity check to ensure the validity of each alpha-numeric character.

The NOTAM-only circuit was eliminated with the conversion to the COMEDS system; the responsibility of suppling NOTAMS to base operations now rests with the weather office. The observer terminal should be used for recipt and transmission of NOTAMS.

Automatic Response Query (ARQ) requests will be made and responses received directly at the work area where needed. Responses will be directed to either the display unit (KD) or the printer according to the directions. This procedure sharply reduces the amount of paper being used.

Automatic Polling

Automatic polling of units on the COMEDS circuit is accomplished by the computer sending an invitation-to-send sequence which causes the KD to respond in one of two ways: (1) If ready to transmit, the KD sends its message beginning at the location of the cursor, or (2) if not ready to transmit, the KD sends a no-traffic response. This polling is repeated for each KD on the loop, thus completing the cycle.

Dissemination Concept

Messages may be sent by the computer at any time. The messages are selectively addressed and copied only by the receiving devices for which they are designated. The concept for the printer and the KD follows:

(1) Printers - The computer sends a receive device conditioning signal. The address code of each printer designated to receive the message will then be sent, followed by the message.

(2) Keyboard Display (KD) - The computer sends a receive device conditioning signal and one KD address code. This will cause the KD to respond in one of two manners: (a) If the KD is in a receive mode, the ready-to-receive response will be sent to the computer which then sends the message to the KD. (b) If the KD is not ready to receive, a not-ready-to-receive response is sent to the computer. The message is sent to the computer, then to the receive-only printer with which the KD is associated.

NOTE: Complete details on procedures and formats were not available at the time of this writing. For a more complete and comprehensive understanding of the system, refer to the latest manual and instructions as they become available.

NAVAL COMMUNICATIONS

Quite often, naval weather units must depend on the naval communications system for the dissemination of weather data. Of the several methods of naval communications available, those utilized most commonly are radiotelegraphy, radioteletype, and radiofacsimile.

Precedence of Message

Precedence indicates to communications personnel the relative order in which a message should be handled and delivered, and the relative order in which the action officer should note its contents. Precedence is assigned by the originator on the basis of the message content and how soon the addressee must have it. Because precedence begins as soon as the message is drafted, the originator and releasing officer should handle the message with the same speed they expect from communications personnel.

No message should be given higher precedence than that which will assure its reaching the addressee in time for action. Unfortunately for communications efficiency, this rule is all too often disregarded. Originators should be reminded by communicators that misuse of precedence tends to destroy the value of all precedence designators.

Procedure signs (or prosigns) are single or multiple letter groups which convey in standard condensed form certain frequently sent orders, instructions, requests, and the like, relating to communications. Among the most important of the prosigns are the precedence prosigns. (See table 7-1.)

Date-Time Groups

All naval personnel whose work brings them in contact with communications must have a thorough knowledge of the communication's use of time.

The approved method of expressing time in the 24-hour system is with hours and minutes expressed as a four-digit group. The first two figures of a group denote the hour; the second two, minutes. Thus, 6:30 a.m. becomes 0630; noon is 1200; and 6:30 p.m. is 1830. Midnight is expressed as 0000—never as 2400—and 1 minute past midnight becomes 0001. The time designation 1327Z shows that it is 27 minutes past 1:00 p.m., GMT. Numbers are prefixed to the time to indicate the day of the month; in other words, to form a date-time group (DTG). The DTG 171327Z Nov 70 means the 17th day of November 1970 plus the time in GMT. Dates from the 1st to the 9th of the month are preceded by the numeral 0.

A date-time group is assigned to a message by the message center at the time a message is prepared for transmission. For standardization, time expressed by a date-time group normally is GMT. The date-time group in a message heading serves two purposes: It indicates the time of origin of the message, and it provides an easy means of referring to the message.

In addition to the external DTG, an encrypted message has a DTG buried within the text. This time is called the true date-time group (TDTG) and it is inserted by the cryptocenter. The TDTG is used when referring to a message that has been encrypted.

The DTG assigned to a general message always has a slant sign (/) and additional digits added to the DTG. Additional digits represent the general message sequential serial number. Example: 102347Z/35 Nov. 70.

Time Conversion Table

The time conversion table (Table 7-2) is useful for converting time in one zone to time in any other zone. Vertical columns indicate time zones. Zone Z is GMT. Time in each successive zone to the right of zone Z is 1 hour later, and to the left of zone Z is 1 hour earlier. Time in each successive shaded area to the right is 1 day (24 hours) later; to the left it is 1 day (24 hours) earlier.

To calculate time in zone U when it is 0500 hours in zone I, for example, proceed as follows: find 0500 in column I and locate the time (1200) in the corresponding line in column U. Inasmuch as 1200 is not in the shaded area, the time is 1200 hours yesterday.

Weather Message Heading

Most weather messages have a heading preceding the weather data enabling the Aerographer's Mate to identify the type and origin of the data received at a glance. Normally, the heading consists of four letters; for example, SAUS. The first two letters identify the type of weather data and the remaining two the geographical area in which the data originated. In the preceding example, the letters SA indicate the message is a surface airways hourly report and the letters US indicate it is from a station in the United States.

A complete discussion on the many different types of weather message headings is covered in chapter 10 of this manual.

Standard Subject Identification Code (SSIC)

Computer scanning devices are now being used by the Navy Communications System to increase the speed of handling naval messages. With the introduction of these scanning devices it became necessary to devise a means of rapid identification for message subject matter. The result is that messages now contain a code which is assigned by the originator and referred to as the Standard Subject Identification Code or more commonly the SSIC.

The SSICs consist of two slants (//), the letter "N", a five digit identification code, and then two more slants. The SSIC is inserted into the message following the security classification as follows:

FM NWSED MEMPHIS
TO DIRNAVOCEANMET WASH DC
UNCLAS //N03140//
etc.

Table 7-1.—Precedence of Messages

Prosign	Designation	Definition and Use	Handling Requirements
Z	FLASH	FLASH precedence is reserved for initial enemy contact messages or operational combat messages of extreme urgency. Brevity is mandatory. Examples: (1) Initial enemy contact reports. (2) Messages recalling or diverting friendly aircraft about to bomb targets unexpectedly occupied by friendly forces; or messages taking emergency action to prevent conflict between friendly forces. (3) Warnings of imminent large-scale attacks. (4) Extremely urgent intelligence messages. (5) Messages containing major strategic decisions of great urgency.	FLASH messages are hand-carried, proc transmitted, and delivered in the order r and ahead of all other messages. Messag lower precedence will be interrupted on circuits involved until handling of the FL message is completed. Time Standard: Not fixed. Handled as fast as humanly p with an objective of less than 10 minute
O	IMMEDIATE	IMMEDIATE is the precedence reserved for messages relating to situations that gravely affect the security of national/allied forces or populace, and require immediate delivery to the addressee(s). Examples: (1) Amplifying reports of initial enemy contact. (2) Reports of unusual major movements of military forces of foreign powers in time of peace or strained relations. (3) Messages that report enemy counterattack or request or cancel additional support. (4) Attack orders to commit a force in reserve without delay. (5) Messages concerning logistical support of special weapons when essential to sustain operations. (6) Reports of widespread civil disturbance. (7) Reports or warnings of grave natural disaster (earthquake, flood, storm, etc). (8) Requests for, or directions concerning, distress assistance. (9) Urgent intelligence messages.	IMMEDIATE messages are processed, transmitted, and delivered in the order received and ahead of all messages of lo precedence. If possible, messages of low precedence will be interrupted on all cir involved until the handling of the IMMEDI message is completed. Time Standard: 30 minutes to 1 hour.
P	PRIORITY	PRIORITY is the precedence reserved for messages that require expeditious action by the addressee(s) and/or furnish essential information for the conduct of operations in progress when ROUTINE precedence will not suffice. Examples: (1) Situation reports on position of front where attack is impending or where fire or air support will soon be placed. (2) Orders to aircraft formations or units to coincide with ground or naval operations. (3) Aircraft movement reports (messages relating to requests for news of aircraft in flight, flight plans, or cancellation messages to prevent unnecessary search/rescue action). (4) Messages concerning immediate movement of naval, air, and ground forces.	PRIORITY messages are processed, tra and delivered in the order received and all messages of ROUTINE precedence. R messages being transmitted should not b rupted unless they are extra long and a v substantial portion remains to be transm PRIORITY messages should be delivered immediately upon receipt at the addresse destination. When commercial refile is r the commercial precedence that most ne corresponds to PRIORITY is used. Time Standard: 1 to 6 hours.
R	ROUTINE	ROUTINE is the precedence to use for all types of messages that justify transmission by rapid means unless of sufficient urgency to require a higher precedence. Examples: (1) Messages concerning normal peacetime military operations, programs, and projects. (2) Messages concerning stabilized tactical operations. (3) Operational plans concerning projected operations. (4) Periodic or consolidated intelligence reports. (5) Troop movement messages, except when time factors dictate use of a higher precedence. (6) Supply and equipment requisition and movement messages, except when time factors dictate use of a higher precedence. (7) Administrative, logistic, and personnel matters.	ROUTINE messages are processed, tra and delivered in the order received and messages of a higher precedence. When commercial refile is required, the lowe commercial precedence is used. ROUTI messages received during nonduty hours addressee destination may be held for m delivery unless specifically prohibited b command concerned. Time Standard: 3 hours — start of business following d

Table 7-1.—Precedence of Messages

ation	Definition and Use	Handling Requirements
FLASH	FLASH precedence is reserved for initial enemy contact messages or operational combat messages of extreme urgency. Brevity is mandatory. Examples: (1) Initial enemy contact reports. (2) Messages recalling or diverting friendly aircraft about to bomb targets unexpectedly occupied by friendly forces; or messages taking emergency action to prevent conflict between friendly forces. (3) Warnings of imminent large-scale attacks. (4) Extremely urgent intelligence messages. (5) Messages containing major strategic decisions of great urgency.	FLASH messages are hand-carried, processed, transmitted, and delivered in the order received and ahead of all other messages. Messages of lower precedence will be interrupted on all circuits involved until handling of the FLASH message is completed. Time Standard: Not fixed. Handled as fast as humanly possible with an objective of less than 10 minutes.
IMMEDIA	IMMEDIATE is the precedence reserved for messages relating to situations that gravely affect the security of national/allied forces or populace, and require immediate delivery to the addressee(s). Examples: (1) Amplifying reports of initial enemy contact. (2) Reports of unusual major movements of military forces of foreign powers in time of peace or strained relations. (3) Messages that report enemy counterattack or request or cancel additional support. (4) Attack orders to commit a force in reserve without delay. (5) Messages concerning logistical support of special weapons when essential to sustain operations. (6) Reports of widespread civil disturbance. (7) Reports or warnings of grave natural disaster (earthquake, flood, storm, etc). (8) Requests for, or directions concerning, distress assistance. (9) Urgent intelligence messages.	IMMEDIATE messages are processed, transmitted, and delivered in the order received and ahead of all messages of lower precedence. If possible, messages of lower precedence will be interrupted on all circuits involved until the handling of the IMMEDIATE message is completed. Time Standard: 30 minutes to 1 hour.
	PRIORITY is the precedence reserved for messages that require expeditious action by the addressee(s) and/or furnish essential information for the conduct of operations in progress when ROUTINE precedence will not suffice. Examples: (1) Situation reports on position of front where attack is impending or where fire or air support will soon be placed. (2) Orders to aircraft formations or units to coincide with ground or naval operations. (3) Aircraft movement reports (messages relating to requests for news of aircraft in flight, flight plans, or cancellation messages to prevent unnecessary search/rescue action). (4) Messages concerning immediate movement of naval, air, and ground forces.	PRIORITY messages are processed, transmitted, and delivered in the order received and ahead of all messages of ROUTINE precedence. ROUTINE messages being transmitted should not be interrupted unless they are extra long and a very substantial portion remains to be transmitted. PRIORITY messages should be delivered immediately upon receipt at the addressee destination. When commercial refile is required, the commercial precedence that most nearly corresponds to PRIORITY is used. Time Standard: 1 to 6 hours.
	ROUTINE is the precedence to use for all types of messages that justify transmission by rapid means unless of sufficient urgency to require a higher precedence. Examples: (1) Messages concerning normal peacetime military operations, programs, and projects. (2) Messages concerning stabilized tactical operations. (3) Operational plans concerning projected operations. (4) Periodic or consolidated intelligence reports. (5) Troop movement messages, except when time factors dictate use of a higher precedence. (6) Supply and equipment requisition and movement messages, except when time factors dictate use of a higher precedence. (7) Administrative, logistic, and personnel matters.	ROUTINE messages are processed, transmitted, and delivered in the order received and after all messages of a higher precedence. When commercial refile is required, the lowest commercial precedence is used. ROUTINE messages received during nonduty hours at the addressee destination may be held for morning delivery unless specifically prohibited by the command concerned. Time Standard: 3 hours — start of business following day.

76.44

Table 7-2.—Time Conversion Table

PREVIOUS DAY	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	SAME DAY
	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	
	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	
	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	
	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	
	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	
	2400	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	
SAME DAY	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	0100	NEXT DAY
	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	
	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	
	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	
	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	
	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	
	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	
	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	
	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	0900	
	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	
	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	
	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	
	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	
	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	
	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	
	1600	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	
	1700	1800	1900	2000	2100	2200	2300	2400	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	
	Y +12	X +11	W +10	V +9	U +8	T +7	S +6	R +5	Q +4	P +3	O +2	N +1	Z 0	A -1	B -2	C -3	D -4	E -5	F -6	G -7	H -8	I -9	K -10	L -11	M -12	

209.439

The SSICs to be assigned may be obtained from the manual for Standard Subject Identification Codes SECNAVINST 5210.11.

The SSICs are not required in messages transmitted over dedicated or closed networks if the message is to remain within the network. This exception as stated in OPNAV Instruction 2100.1 includes closed weather networks such as NEDN and COMEDS and NEDS. Any open network must include the SSIC.

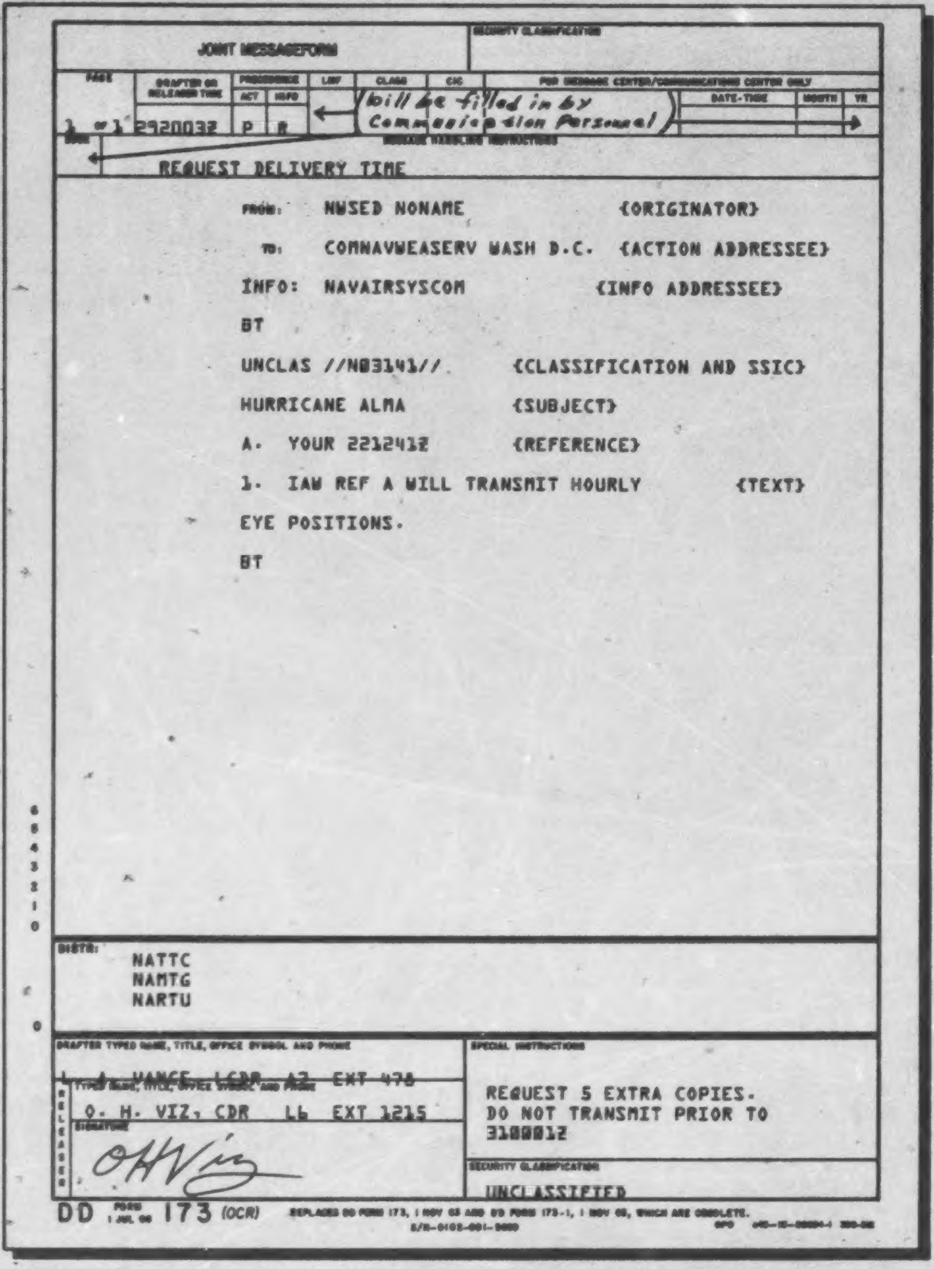
Joint Messageform (DD Form 173) (OCR)

Joint messageform (DD Form 173) (OCR) replaces messageforms currently in use. Conversion to this joint form is for the purpose of facilitating continuity within the communication systems and provide an efficient means for automatic processing by which messages coming into the computer system are translated into machine language. (Optical character recognition (OCR) systems are fast becoming an important link to electronic data processing systems as optical readers provide computer input by reading directly from typewritten copy and converting this data into electronic impulses recognizable to the computer.) The procedures for use are the same as presented in preceding paragraphs. An example of a completed DD Form 173 (OCR) is illustrated in figure 7-20.

Radioteletype and Radiofacsimile

Fleet Weather Centrals and Facilities originate major radioteletype and radiofacsimile broadcasts. The frequencies and schedules of these broadcasts are listed in the Worldwide Marine Weather Broadcasts Manual.

A myriad of weather reports are received by Fleet Weather Centrals and Facilities daily from operating weather units. In addition, FLEWEACENs and FLEWEAFACs have a requirement for preparing forecasts and warnings for their areas of responsibility. Transmission of this weather data via radioteletype is similar to the procedures described earlier in this chapter—a message tape must be prepared and transmitted on schedule. Transmission of weather charts via radiofacsimile requires proper installation of the weather chart on the facsimile transceiver and a scheduled transmission. Procedures for the transmission of weather data via radioteletype and radiofacsimile vary at different naval weather units. Refer to local operating instructions for proper procedures.



JOINT MESSAGEFORM

SECURITY CLASSIFICATION

PAGE	DRAFTER OR RELEASER TIME	PRECEDENCE ACT	PRECEDENCE INFO	LMF	CLASS	CIC	FOR MESSAGE CENTER/COMMUNICATIONS CENTER ONLY DATE-TIME	MONTH	YR
1 of 1	292003Z	P	R	←	(will be filled in by Communication Personnel)		→		

BOOK

MESSAGE HANDLING INSTRUCTIONS

REQUEST DELIVERY TIME

FROM: NWSED NONAME {ORIGINATOR}

TO: COMNAVWEASERV WASH D.C. {ACTION ADDRESSEE}

INFO: NAVAIRSYSCOM {INFO ADDRESSEE}

BT

UNCLAS //N03141// {CLASSIFICATION AND SSIC}

HURRICANE ALMA {SUBJECT}

A. YOUR 221241Z {REFERENCE}

1. IAW REF A WILL TRANSMIT HOURLY {TEXT}

EYE POSITIONS.

BT

DISTR:
NATTC
NAMTG
NARTU

DRAFTER TYPED NAME, TITLE, OFFICE SYMBOL AND PHONE
L. A. VANCE, LCDR A3 EXT 478

RELEASER TYPED NAME, TITLE, OFFICE SYMBOL AND PHONE
O. H. VIZ, CDR L6 EXT 1215

SIGNATURE
OHViz

SPECIAL INSTRUCTIONS
REQUEST 5 EXTRA COPIES.
DO NOT TRANSMIT PRIOR TO
310001Z

SECURITY CLASSIFICATION
UNCLASSIFIED

DD FORM 1 JUL 66 173 (OCR) REPLACES DD FORM 173, 1 NOV 63 AND DD FORM 173-1, 1 NOV 63, WHICH ARE OBSOLETE.

209.355

Figure 7-20.—Completed messageform DD Form 173 (OCR).

FAA PROCEDURES

Area circuit stations, from which weather data is collected, communicate with the WMSC (Weather Message Switching Center) over half-duplex multipoint circuits. Data are collected from stations on these circuits by use of a polling procedure. The polling code is transmitted by the WMSC activating only the polled station's transmitter. If a reply is not received within a specific time period, the next station is polled. If a reply is received, the data is stored for relay by the WMSC. To avoid accidental loss of the end of a message, the WMSC waits a specified length of time after the apparent completion of each station's transmission before polling the next station. On these polled circuits there are three collection periods called scans. The first scan is the A1 Scan, which is polled at H+00 for scheduled data only. The only interruption to this scan would be an urgent message in which the circuit is manually broken into by the station transmitting the urgent message. The next two scans are the A2 and A3 Scans which are for unscheduled data at H+21 and H+39 respectively.

All stations will be polled during the collection periods. If a station does not respond to a poll during a scheduled message collection period, the station is repolled at the end of each polling cycle; if the station still does not respond, a no-report message is generated by the WMSC.

Coding and tape preparation of the FAA circuits is too lengthy for discussion in this manual and is not used by most military stations. For further information on these procedures, refer to the FAA Flight Services Manual 7110.10( ) chapters 4 and 5.

CHAPTER 8

OFFICE EQUIPMENT

The Aerographer's Mate throughout his career will have a need to reproduce many different types of weather charts, forecasts, and other pertinent data for local dissemination and intra-office use. Various types of office equipment, such as the Ditto, Xerox, and Ozalid machines, are in use throughout NAVOCEANMET. The equipment in use has improved product output and saved valuable time.

In this section the operation, maintenance, and safety precautions of reproduction and local dissemination equipment will be discussed. Many models are in use today and it is beyond the scope of this manual to discuss each model. Most office equipment is delivered with operator and maintenance manuals. Refer to these manuals for the model in use at your office.

REPRODUCTION EQUIPMENT

Many different models of the Ditto, Xerox, and Ozalid machines are in use, depending on the needs of the weather office. The Ditto machine requires the original material to be placed on a special master so it can be reproduced. The Xerox or Ozalid machines will reproduce any clear original.

DITTO MACHINES

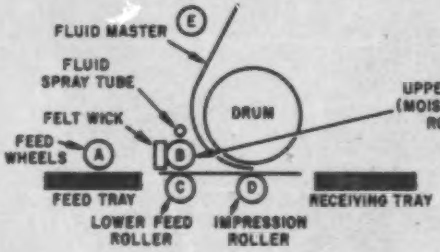
The Ditto machine is a spirit process duplicator. An advantage of the Ditto machine is its compact size, while a disadvantage is the small number of legible copies that can be reproduced from the ditto master. In most weather offices, the Ditto machine is used to reproduce the daily forecast, watch bills, or other data when a limited quantity is needed. Copies varying in size from 8 x 10 inches to 8 1/2 x 14 inches can be produced.

Ditto Master

The ditto master consists of a white typing overlay that is attached to a sheet of thickly coated carbon paper separated by a protection sheet. Typing or stylus impressions cause the carbon to be imprinted on the reverse side of the overlay when the protection sheet has been removed. Ditto masters can usually be obtained in purple, red, green, yellow, black and blue colors. By replacing the usual carbon back with other colored carbons, the daily forecast can be produced in multiple color. Purple is used most often as the base color because it normally produces a larger number of legible copies.

Operation

The ditto duplicating process is illustrated in figure 8-1. Feed-wheel A pushes the blank paper to feed rollers B and C. The fluid spray tube distributes the fluid to the upper feed roller B. Roller B moistens the paper while roller C pushes the paper uniformly against roller B and absorbs any excess fluid. The impression roller D presses the moistened paper against



129.41

Figure 8-1.—The Ditto fluid master duplicating process.

the fluid master E which is fastened to the drum by a clamp, and then ejects the finished copy into the receiving tray.

Maintenance

The ditto machine is practically maintenance free. If maintenance is required, contact the company furnishing these services or maintenance personnel of your unit. Keep the exterior and the drum clean. When the machine is not in use, the main power switch is kept in the OFF position, and the dust cover should be placed over it.

Safety Precautions

The duplicating fluid used in the machines is highly flammable and toxic. Therefore, DO NOT smoke in the area of the ditto machine and ensure there is proper ventilation at all times.

XEROX MACHINES

The Xerox machine has added a new dimension to the reproduction capabilities of most weather offices.

The operator in most cases can take an original "as is" and reproduce any number of copies in a matter of minutes or even seconds.

NAVOCEANMET uses various sizes and models of the Xerox copier. Some of the models that you may encounter are the 3600, 4000, and 7000 series. The information given in the following section will cover the 7000 series shown in figure 8-2.

All Xerox machines operate on the principle of the dry electrical process. Both the items and terms used in the operation of Xerox machines will be discussed.

Copy Paper

The recommended copy paper used with the Xerox copier is from 16 to 32 pound long grain paper. The size will vary with the type and capability of the copier, ranging from 8 x 10 inches to 8 1/2 x 14 inches. When paper is loaded, some models use only the "curl side" type, while others use the "two-sided" type. When the "curl side" type is used, ensure the curl is DOWN. Use only one size paper at a time. Mixing paper sizes and types will result in misfeeds.

Misfeed

A misfeed is the term used to define the condition that results when the paper does not feed properly or is jammed during the normal cycle. This results in an overload and the Xerox will automatically shut OFF. All misfeeds must be cleared before normal operations can be continued. Refer to the operator's manual for proper procedures for clearing a misfeed.

Toner

Toner is the fine black powder used to form the copy image. Toner is dispensed from the toner well located under the top cover. A small amount of toner is dispensed with each copy. The amount of toner dispensed is controlled by the toner dial setting. Check the toner level in the toner well daily and maintain the proper operating level.

Print Density

This term applies to the lightness or darkness of the copy. Print density may be adjusted by increasing or decreasing the toner flow.

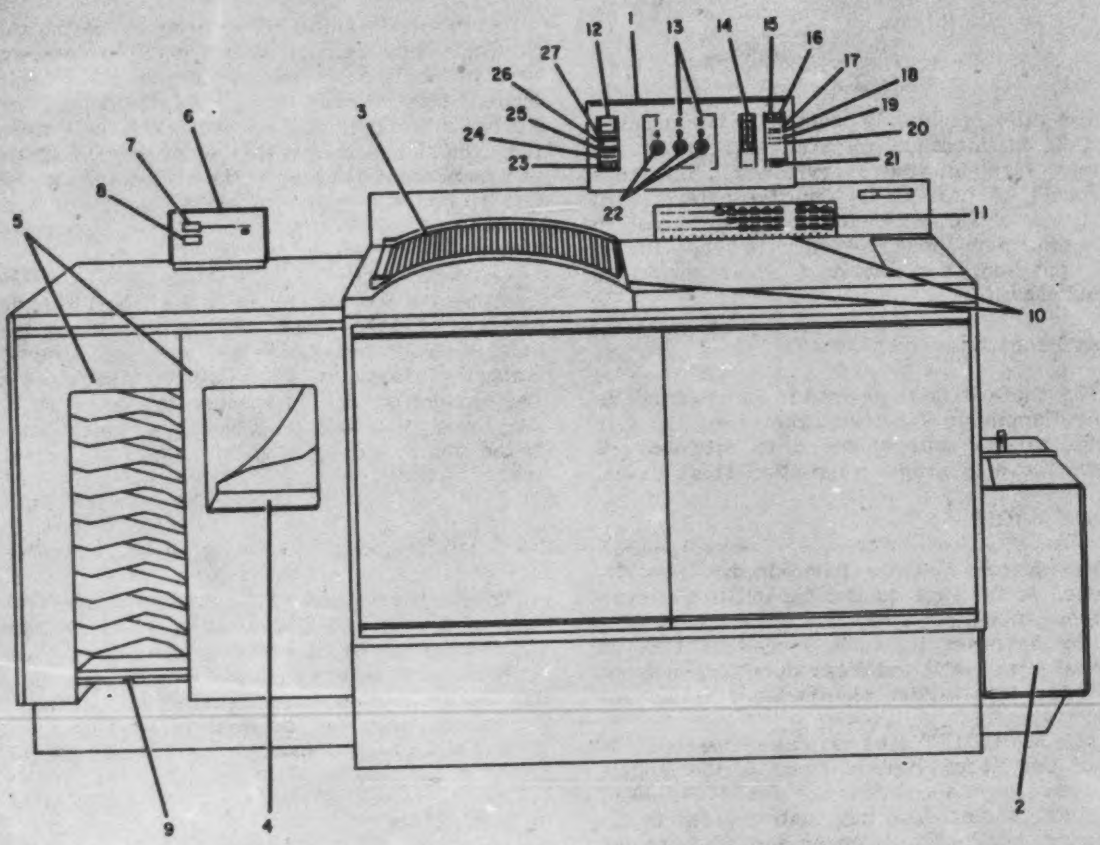
Some models are equipped with a light original feature button for improving the quality of the image when the original is weak or light. Blueprint is a good example of a light original.

Key Operator

The Xerox Corporation offers a course of instruction for units equipped with a Xerox machine. This course of instruction trains the Key Operator in the proper use of the Xerox, proper maintenance, and servicing procedures. One or two individuals within the command should be designated as Key Operators. Listed in Table 8-1 are some of the duties of the Key Operator.

Operating Procedures

Set print quantity at the desired number of copies. If you are copying a light or weak original, use the light original feature button. Raise the document cover and insert the document with the original face down and with the right side against the side scale. Ensure the original is centered and close the cover. When the



209.431

1. Control Console.
2. Paper Tray.
3. Document Area.
4. Sorter Receiving Tray.
5. First Bin and Transition Module.
6. Sorter Control Unit.
7. Start Sorter Button.
8. Stop Sorter Button.
9. Misfeed Indicator.
10. Size Scale.
11. Reduction Guide.
12. Start Print Button.
13. Count Indicator.
14. Reduction Selector Buttons.
15. Power ON Button
16. Power OFF Button
17. Letter Paper Indicator.
18. Legal Paper Indicator.
19. Light Original Indicator.
20. Call Key Operator Indicator.
21. Light Original Button.
22. Print Quantity Selector.
23. Stop Print Button.
24. Reduction Indicator.
25. Select Reduction Indicator.
26. NOT Ready Indicator.
27. Ready Indicator.

Figure 8-2.—Xerox Model 7000 with Sorter.

Table 8-1.—Duties of the key operator

Daily

1. Ensure the Xerox is ON.
2. Check toner and fuser oil, add more when necessary.
3. Clean document glass and cover.
4. Load paper as needed.
5. Clear misfeeds.
6. Check supplies, order as needed.
7. Ensure copier is locked.
8. For assistance, refer to operator manual or call technical representative.

READY light is lighted, press the start print button. The quantity print selector can be changed after the run begins as long as the number selected is higher than the number indicated on the counter indicator. When fewer copies are needed than selected, press the stop print button and the machine will automatically stop. When photographs are copied, use the halftone screen.

Copy Reduction

The Xerox 7000 has a reduction capability for reducing the size of the original. The amount of reduction is dependent upon the selector button pushed. The reduction buttons are numbered 1 to 5. The higher the number the more reduction. When any of the reduction buttons are pushed, the NOT READY indicator will come on while the 7000 is adjusting to the new requirement. Once the READY light comes on, press the start print button.

Maintenance

Normally major maintenance and repairs are handled through the Xerox technical representative. Routine maintenance by the Key Operator consists of those duties outlined in Table 8-1. When necessary, refer to the operator's manual for detailed information.

Safety Precautions

Some of the safety precautions to be aware of in the operation of these machines are as follows:

1. Avoid touching the drum at all times; the drum is specially treated and fingerprints could cause permanent damage to the drum.
2. Avoid contact with the fuser, it may be hot and cause severe burns.
3. Avoid getting fuser oil on your hands; wash with soap and water to remove.
4. Never mix paper sizes.
5. When you clear a misfeed, if the paper tears, call the Xerox representative.

OZALID MACHINES

The Ozalid machine is used to copy larger types of originals. It has a high intensity light that exposes all areas that are data free. It uses the chemical developing process, usually ammonia. The copy paper is a Diazo type of material. Diazo materials are products that have been coated with a light sensitive dye that develops when exposed to ammonia.

Starting the Machine

A short warmup period is required before material can be fed into the machine. Always follow the manufacturer's instructions during machine operation.

1. Make sure that the developer drain tube is inserted in the residue bottle. Then fill the storage tank with ammonia. If bubbles are encountered in the feed system due to increased temperature or high altitude, the ammonia should be diluted with cold water. Usually a 1/8 to 1/4 dilution is sufficient.

2. After the ammonia storage tank has been filled, turn on the main switch and adjust the ammonia feed to 50-60 drops per minute. At high speeds (30 feet per minute and above) the drops per minute can be increased. On virtually all modern, large-size Ozalid machines, ammonia feed is automatically increased and decreased to correspond with variations of machine speed.

3. The machine should be warmed up for approximately 20 minutes or until the operating

temperature is between 180° and 210°. Time and temperature may vary; therefore, always follow the manufacturer's instructions. Feed the material into the machine with the original on top, adjusting the speed of the machine so that a clear print is obtained.

Printing speed is dependent on the translucency of the original and the density of the opaque image, also on the type of sensitized material used.

Stopping The Machine

When stopping the machine, turn the ammonia flow off, then feed a sheet of porous wrapping paper 16 inches wide into the machine. Stop the machine with the paper in position around the printing cylinder and between the sealing sleeve and the perforated tank. This will prevent the sleeve from sticking to the perforated tank top and will also protect the belts from the heat of the cylinder while it is cooling.

Adjustments and Maintenance

Normally, when the machine is first installed, no adjustments are required. Occasionally, however, some readjustments may be necessary due to atmospheric changes which may cause shrinkage or expansion of some of the belts. These adjustments should be performed in accordance with manufacturer's instructions and then only by qualified personnel. Maintenance is required on a periodic basis. Specific daily, weekly, monthly, semiannual, and annual maintenance tasks are required and are outlined in the manufacture's instructions.

Safety Precautions

1. Ammonia is a toxic solution so ensure proper ventilation.

2. Handle the lamp assembly with great care. It is fragile and expensive. Do not attempt to remove the lamp from the machine until it has cooled. Always rest the lamp assembly flat on a table; never stand it on end.

3. During machine operation, the ammonia feed regulator should never be turned completely off. If the machine is left running and no moisture is entering the developer section, the evaporation tray and heater rods are likely to be warped due to excessive heat.

LOCAL DISSEMINATION EQUIPMENT

Many hours of valuable time are needed during the normal course of the day to disseminate local weather conditions and forecasts. To aid in the dissemination of pertinent data, most weather offices use the telephone and the Code-A-Phone.

CODE-A-PHONE

The Code-A-Phone in most weather offices is used to record the daily forecast, local warnings, tidal, and astronomical data. The amount and type of data to be recorded will vary, depending on the needs of the office and the length of tape supplied with the equipment. The recorded data is usually updated at 6 hour intervals to coincide with the Aviation Forecasts. It may be revised more often as weather conditions dictate. The Code-A-Phone has proven to be invaluable in this capacity.

The typical Code-A-Phone, as shown in figure 8-3, is a self-contained instrument. It operates on the same principle as a tape recorder. The mouth piece acts as the microphone and the ear piece as a listening device. Most Code-A-Phones have a playback and an automatic answering capability. The playback capability enables the individual to check the tape for errors after making the recording. The automatic answering capability permits the caller to dial directly into the weather office and receive the recorded information without anyone answering the phone. This saves time for the caller

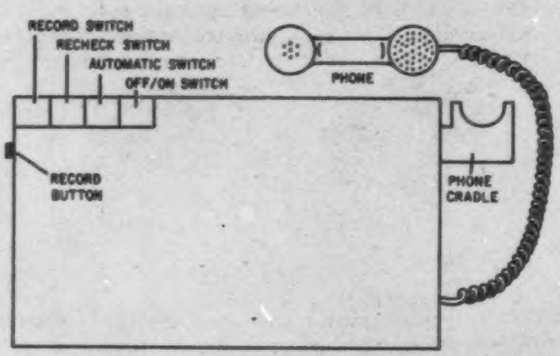


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Figure 8-3.—Typical Code-A-Phone.

and the forecaster, who otherwise may have to continually repeat the same weather information.

Operation

The basic steps to follow when using the Code-A-Phone are given below:

1. Ensure the machine is ON, remove phone from cradle.
2. Push the recording cycle switch.
3. Push the recording button.
4. Record the data.
5. Using the recheck switch, check the recording.
6. Set the machine to the automatic position and return the phone to its cradle.

Procedures may vary with each model of the Code-A-Phone. Refer to the operator's manual for your particular model.

Maintenance

The Aerographer's Mate's maintenance responsibility is limited to keeping the exterior clean. All interior maintenance is the responsibility of the local area phone company.

TELEPHONES

The telephone is a rapid type of communication that has saved many hours. In many cases the caller does not have to come to the weather office to get questions answered or to get a weather briefing.

There are a few easy-to-acquire habits which make use of the telephone more pleasant and more effective. If you are not already observing them, it will be well worth your while to develop them. To avoid misunderstandings while using the phone, speak clearly and distinctly. Avoid gestures, the person at the other end cannot see you. Listed below are some of the most common voice deficiencies.

1. Lack of emphasis
2. Poor volume
3. Weak enunciation
4. Errors in pronunciation
5. Poor pitch

They can all be eliminated by (1) practicing oral reading; (2) listening to professionals' speech habits; (3) taping and listening to your own voice and working to correct deficiencies.

Always be polite but professional. Open a phone conversation with a phrase that identifies your office and you. If a caller fails to identify himself, ask him tactfully for his name.

If the caller must wait while you collect the information he wants or wait for the forecaster to come to the telephone, inform him of the delay and the reason for it. When the person being called is not available, ask if you may help or if there is a message. You may be able to help and the caller will not have to call the second time.

CONVENIENCE-TYPE EQUIPMENT

One of the most important pieces of office equipment is the typewriter. Many makes and models are available for use. It is beyond the scope of this manual to cover all makes and models, though we will discuss them in general.

TYPEWRITERS

Currently there are two types in use, the manual and the electric. The typewriter in your office may be heavy and rugged looking, but in fact, it is a very delicate instrument. Treat it like one and give it daily care. A typewriter in first-class condition is easier to operate and turns out a better looking product. Observe the routine procedures listed for best results from your typewriter.

Care of Typewriters

1. Keep your typewriter covered when not in use. Always cover it or close it into the desk at the end of the day.
2. Keep it clean by wiping the outside with a soft dry cloth and dusting the inside with a long-handled brush.
3. Clean the type daily with a stiff brush, and it seldom will be necessary to use chemicals.
4. Take care in erasing to move the carriage to one side so that erasure crumbs will not fall onto the mechanism.
5. Disengage the paper feed rolls from the platen (large rubber roller) whenever you are not using the machine. On most typewriters

you do this by pulling a lever on the right side of the carriage. This is to prevent flat spots from developing on the feed rolls and platen.

Maintenance

At regular intervals you should give the typewriter a more thorough cleaning. Frequency of these cleanings will depend on the amount of use the typewriter receives. In general, it is recommended that the following procedures be carried out weekly:

1. Clean the carriage rails and marginal stop bar, using a cloth slightly moistened with oil. Move the carriage back and forth in the process.
2. Clean the platen or cylinder. Remove, if possible, and wipe with a cloth moistened with a very small amount of denatured alcohol or cleaning fluid. Do not wipe off; allow the fluid to evaporate.
3. Clean the type, using a short-bristled brush. Tap lightly with the points of the bristles to loosen the dirt; then brush lightly.
4. Brush the type bar segments and dust the interior of the machine. Use a long-handled brush, brushing toward the front of the machine. By elevating a few type bars at a time, you can reach into the mechanism. Do not force the bars. Use a soft cloth alternately with the brush.
5. Wipe the sides and back of the machine.
6. Turn the power off on electric typewriters when they are not being used.
7. Disconnect the plug on the electric typewriter at the end of each work day.

If operating instructions for your typewriter are available, they will help you identify its parts and give you additional information about its care.

If further oiling or repair work is needed, the machine should be turned over to a typewriter mechanic.

Safety Precautions

When it becomes necessary to move the typewriter, the following precautions should be taken.

1. Be sure your typewriter is properly placed on the desk, or secured to the well type of desk, so that it will not fall.
2. In lifting a typewriter, grip it by its case, NEVER by its carriage.
3. NEVER attempt typewriter repairs of an electrical nature.

CHAPTER 9

SPECIALIZED METEOROLOGICAL EQUIPMENT AND THEIR USES

Specialized meteorological equipment range from equipment utilized in observing atmospheric conditions aloft to the various computer systems that generate numerical products in support of the operating forces.

The objective of this chapter is to acquaint the Aerographer's Mate with the function, basic operation, care, and applicable safety precautions of specialized meteorological equipment.

UPPER AIR/WIND EQUIPMENT

Upper air/wind equipment may be divided into six general categories: radiosonde transmitters, test and calibration, balloon inflation, balloon launch, tracking, and assoicated hand calculators, computers, and plotting boards.

RADIOSONDE TRANSMITTER

The radiosonde transmitter is a balloon-borne, battery-powered instrument used together with ground-receiving equipment to obtain a vertical profile of the atmosphere in terms of pressure, temperature, and relative humidity. The basic radiosonde transmitter contains an aneroid baroswitch for measuring pressure, a white-coated thermistor for temperature, and a carbon hygristor for relative humidity. Two basic types of radiosondes are the 1680- and 403-MHz. Ashore, upper-air stations use the 1680-MHz, while ships use the 403-MHz. Radiosonde Observations, FMH No. 3, contains additional information on these instruments.

TEST AND CALIBRATION EQUIPMENT

In order to ensure a high percentage of successful radiosonde and rawinsonde flights, a thorough preflight check of the radiosonde and associated battery pack must be performed and ground equipment must be maintained at a high level of performance. Usually electronics technicians service ground equipment.

Signal Generators

Signal generators are used to calibrate radiosonde recorders. A signal generator supplies the audio input frequencies which are necessary for accurate computation of frequencies. A signal generator of the type used with meteorological equipment simulates the audiofrequencies the radiosondes would send.

Detailed calibration procedures may be found in the applicable instrument handbook.

Humidity Chamber ML-428/UM

Humidity Chamber ML-428/UM is provided to secure a stable environment of temperature and relative humidity for conditioning 403-MHz radiosondes prior to release.

The humidity chamber is equipped with an automatic switching device. This switching device consists of a synchronous timer unit which automatically connects the three elements of the radiosonde in a predetermined sequence. This, in turn, allows the operator to obtain data essential to the preflight check of 403-MHz radiosondes.

Refer to the instructions that accompany this equipment for detailed operating and maintenance procedures.

Radiosonde Baseline Check Sets AN/GMM-1( ), AN/GMM-3, and AN/UMM-1

Baseline check sets are calibration chambers designed for use with radiosondes used by the Naval Weather Service.

Equipment supplied with these check sets includes a remote switching control for control of the radiosonde only. It also includes a calibration chamber control mounted on the chamber which provides all the controls necessary to operate both the check set and the installed radiosonde.

For complete information on the operation and maintenance of these check sets, refer to the appropriate technical manuals.

TEST SET TS-538/U.—This test set performs as a frequency meter and power output meter for the AN/AMT-4 and J006A radiosondes. It is also capable of simulating the AN/AMT-4 radiosonde to check the sensitivity, bandwidth, and tracking accuracy of the AN/GMD-1 and -2 rawin sets.

BATTERY TEST SETS.—The standard battery tester is a twin-voltmeter instrument used to measure A and B battery voltages of radiosonde batteries. Both A and B voltages may be read directly on separate voltmeter dials simultaneously.

BALLOON INFLATION EQUIPMENT

Balloons

Most of the balloons used in the Naval Weather Service are made of synthetic rubber (neoprene). The film thickness of the inflated balloons is extremely small, and the balloons are very delicate during storage or preflight preparations, the smallest cut, bruise, or scratch will seriously affect the altitude at which the balloon will burst. Therefore, the requirement for careful balloon handling is essential.

PILOT BALLOONS.—The balloons used to obtain pilot balloon observations (PIBALs) are of two sizes: 30-gram or 100-gram. They are colored either red, black, or white. These different sizes and colors were designed for use under various weather conditions. Select the balloon size and color according to the instructions contained in Winds-Aloft Observations, FMH No. 5.

RADIOSONDE AND RAWINSONDE BALLOONS.—These balloons are manufactured in various sizes ranging from 300- to 1200-grams. There is no standard balloon size. They differ from pilot balloons in that they are uncolored, larger, thinner, and more flexible.

BALLOON CONDITIONING.—As a result of exposure to relatively low temperatures and extended periods in storage, neoprene balloons suffer a partial loss of elasticity through crystallization. Neoprene balloons used in this state will burst prematurely. Therefore, if storage conditions warrant, all neoprene balloons will be conditioned to ensure maximum elasticity before use in accordance with instructions contained in the appropriate FMH.

Helium Regulator

The helium regulator is used to provide a low-pressure helium source for balloon inflation. When connected to a helium cylinder, the regulator provides an indication of cylinder pressure, a regulated helium outlet pressure suitable for balloon inflation, and an indication of the number of cubic feet remaining in the cylinder.

Universal Balloon Balance (ML-575UM)

The universal balloon balance is used to determine buoyancy and to control the inflation of 10-, 30-, and 100-gram balloons. The set contains adapters, a valve body, and a weight pan. These items are packed in a small wooden box.

Balloon Inflation Nozzle Weight Kit (MK-216/GM)

This inflation kit is used to determine the buoyancy and to control the inflation of a radiosonde balloon. The set contains two nozzle assemblies of different size for large- and small-necked balloons, a brass weight with mounting post, and a weight stack of assorted weights.

BALLOON LAUNCH

Balloon Shroud

Balloon shrouds are fabric canopies used to handle and to release inflated radiosonde balloons in high or gusty winds. The shroud is a nylon parachute-like cover, 6 feet in diameter, with four flaps that fold almost completely around the inflated balloon, but which have sufficient spacing between the flaps to allow the neck of the balloon to protrude. (Each flap has a handle.) On the top of the shroud is an eyepiece to which a string can be tied. The string may be tied to some fixed object or held by another person during the release. When hydrogen is used a special static free shroud should be utilized.

Train Regulator

The radiosonde/rawinsonde train regulator consists of a frame, reel, and braking mechanism. The regulator is furnished with approximately 60 feet of nylon cord wound on the reel. The braking mechanism permits the weight of the radiosonde to unwind the cord at the nominal rate of 12 feet per minute. The train regulator is attached between the parachute and the radiosonde and facilitates releases during strong or gusty winds.

Parachute

The parachute is a lightweight, expendable, paper device used to slow the descent of a balloon-borne radiosonde after the balloon has burst. It minimizes the danger to personnel and reduces or minimizes property damage from the falling radiosonde. The parachute should be used for ALL upper air soundings unless there are specific instructions to the contrary.

TRACKING EQUIPMENT

Shore-Type Theodolite

The theodolite is used in taking pibals to measure elevation and azimuth angles of a pilot balloon.

The shore-type theodolite, AERO-1928-USN or ML-474, is similar in many respects to a surveyor's transit, with certain modifications necessary to adapt it to pibal tracking. (See figure 9-1.) The telescope, supported over the center of the upper plate by a yoke standard, is mounted for rotation in both the vertical and horizontal planes. The theodolite telescope differs from the transit telescope. The theodolitz's line of sight is bent through an angle of 90°, placing the objective lens and eyepiece at right angles to each other. A glass prism conveys the image from the objective lens to the eyepiece, which remains stationary in the vertical plane, while the objective lens moves up and down in tracking the balloon. To avoid the use of two additional lenses and a subsequent reduction in light, theodolites have nonerecting eyepieces, and the image appears inverted. By rotating an internal spiral cam attached to it, the eyepiece is focused on cross-hairs provided for use in centering the balloon in the field of the telescope.

For detailed information on the operation and maintenance of the shore-type theodolite refer to FMH No. 5 and the handbook of overhaul instructions, NA 50-30WH-1.

Shipboard Theodolite

The shipboard theodolite (figure 9-2) is used in taking pibals at sea. This theodolite consists of an enclosed optical system with an artifical horizon assembly for operation at night or on days when the horizon is not visible. Ray filters are used to improve visibility. The vertical and horizontal scales are used for obtaining elevation angle and azimuth angle readings. The theodolite is mounted on a gimbal assembly base plate which screws onto a tripod. A counterweight on the counterbalance shaft attached to the gimbal assembly tends to keep the instrument in a vertical position with minimum follow of the ship's roll and pitch.

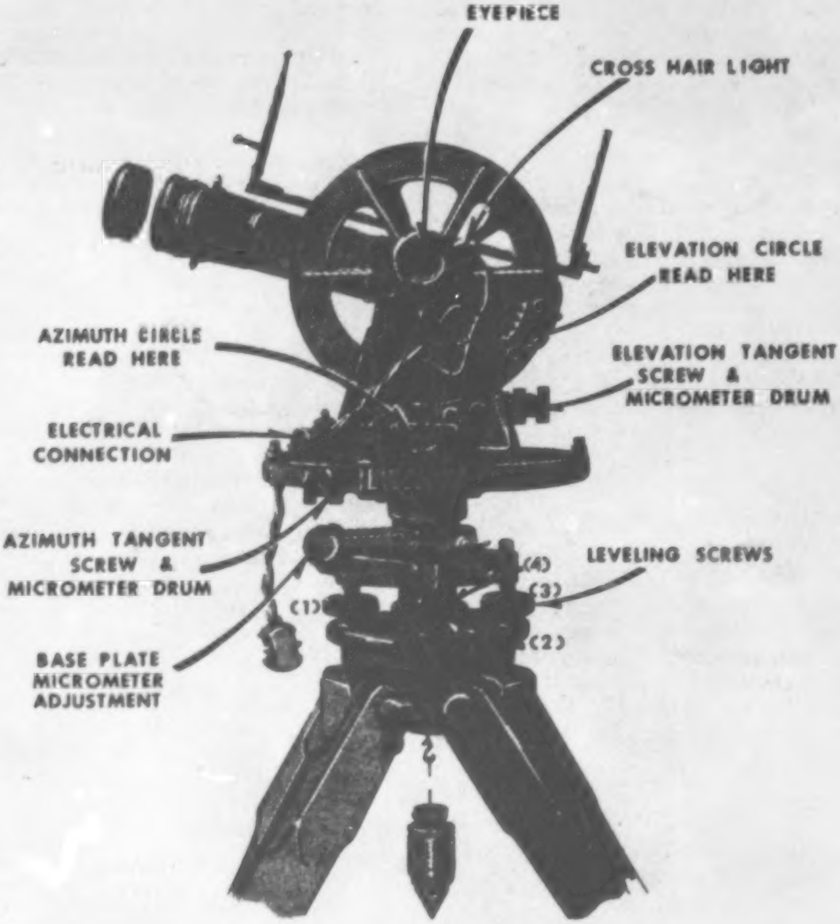
For detailed operating and maintenance instructions refer to the Handbook, Operation and Maintenance Instructions, Shipboard Theodolite, NA 50-30FR-522.

Radiosonde Recorders/Receptors/Receivers

RADIOSONDE RECORDER AN/TMQ-5( ).—Radiosonde Recorder AN/TMQ-5( ) records weather information in graphic form that is transmitted from a balloon-borne radiosonde. It is normally used when taking an upper air sounding with AN/GMD-1( ) equipment which employs a 1680-MHz radiosonde.

The Operator's Manual for this recorder contains detailed instructions on its operation and maintenance.

RADIOSONDE RECEPTOR AN/SMQ-1( ).—Radiosonde Receptor AN/SMQ-1( ) (fig. 9-3) is an electronic meteorological device which receives, amplifies, demodulates, and graphically records signals emitted from a balloon-borne 403-MHz radiosonde. The receptor covers a frequency range of 390 to 410 MHz. The radiosonde transmits data in the form of pulsed


EYEPIECE
CROSS HAIR LIGHT
ELEVATION CIRCLE READ HERE
AZIMUTH CIRCLE READ HERE
ELEVATION TANGENT SCREW & MICROMETER DRUM
ELECTRICAL CONNECTION
AZIMUTH TANGENT SCREW & MICROMETER DRUM
LEVELING SCREWS
(4)
(3)
(1)
(2)
BASE PLATE MICROMETER ADJUSTMENT

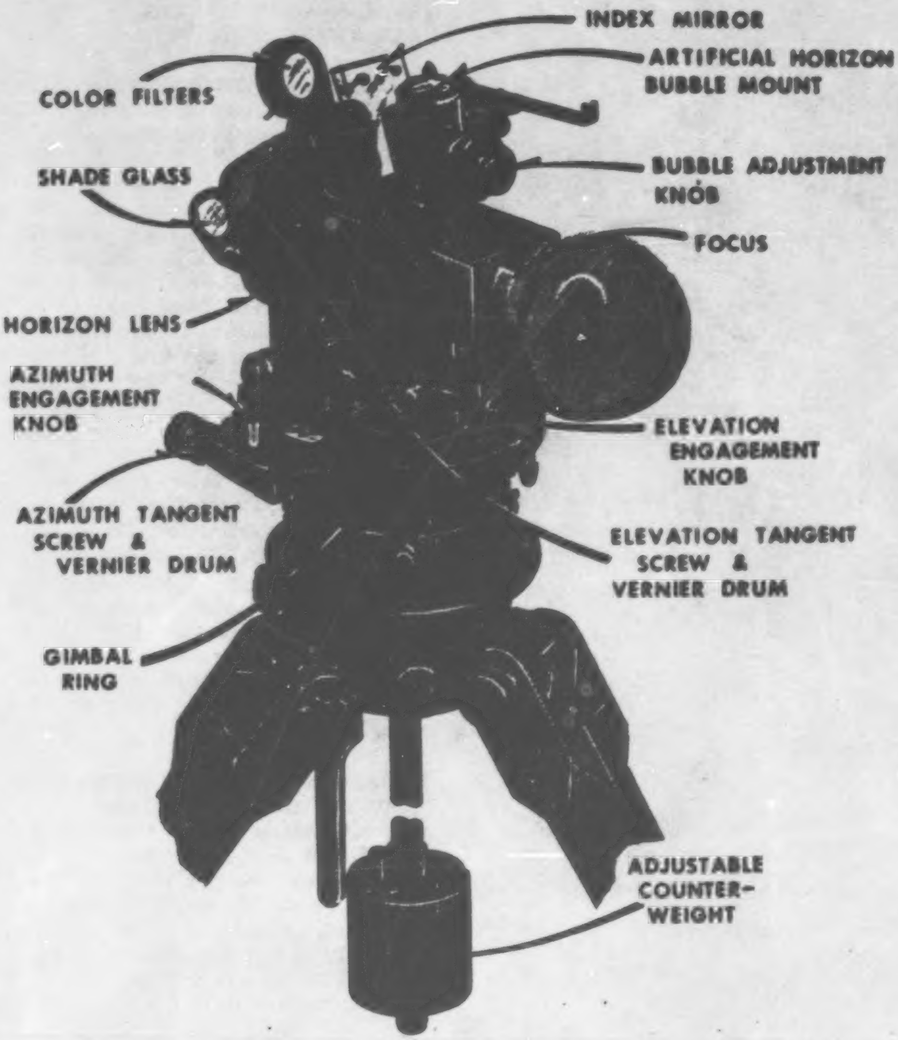
209.99

Figure 9-1.—Shore-type theodolite (ML-474).

RF (radiofrequency) signals which are modulated at an audio rate controlled by the temperature, pressure, and relative humidity of the atmosphere through which the radiosonde passes. Radiosonde Receptor AN/SMQ-1( ) is designed for shipboard use. However, with proper equipment modifications, the AN/SMQ-1( ) may be used as backup gear for the AN/TMQ-5( ) at shore stations.

This receptor is maintained under the Maintenance and Material Management System (3-M). Information pertaining to the 3-M system may be found in the Standard Navy Maintenance and Material Management System Manual, OPNAV 43P2, or the latest revision to the Military Requirements for Petty Officer 3 & 2 rate training manual. Detailed instructions on operating principles and procedures may be found in the Technical Manual for Radiosonde Receptor AN/SMQ-1A, NA 50-30SMQ1A-501.

RADIOSONDE RECEIVER AN/SMQ-3.—This receiver is similar in appearance and controls and performs the same function as the AN/SMQ-1( ). Detailed information on this receiver may be found in the Technical Manual


INDEX MIRROR
ARTIFICIAL HORIZON BUBBLE MOUNT
COLOR FILTERS
SHADE GLASS
BUBBLE ADJUSTMENT KNOB
FOCUS
HORIZON LENS
AZIMUTH ENGAGEMENT KNOB
ELEVATION ENGAGEMENT KNOB
AZIMUTH TANGENT SCREW & VERNIER DRUM
ELEVATION TANGENT SCREW & VERNIER DRUM
GIMBAL RING
ADJUSTABLE COUNTER-WEIGHT

209.100

Figure 9-2.—Shipboard theodolite.

for Receiving Set, Radiosonde AN/SMQ-3, NA50-30-SMQ-3-1.

CALCULATORS, COMPUTERS, AND PLOTTING BOARDS

Various types of calculators, computers, and plotting boards are utilized during the course of an upper air or winds aloft observation. Instructions for their proper use may be found in the appropriate FMH or on the individual item itself.

COMPUTER EQUIPMENT

Computer are daily playing a larger part in the field of communications. The speed with

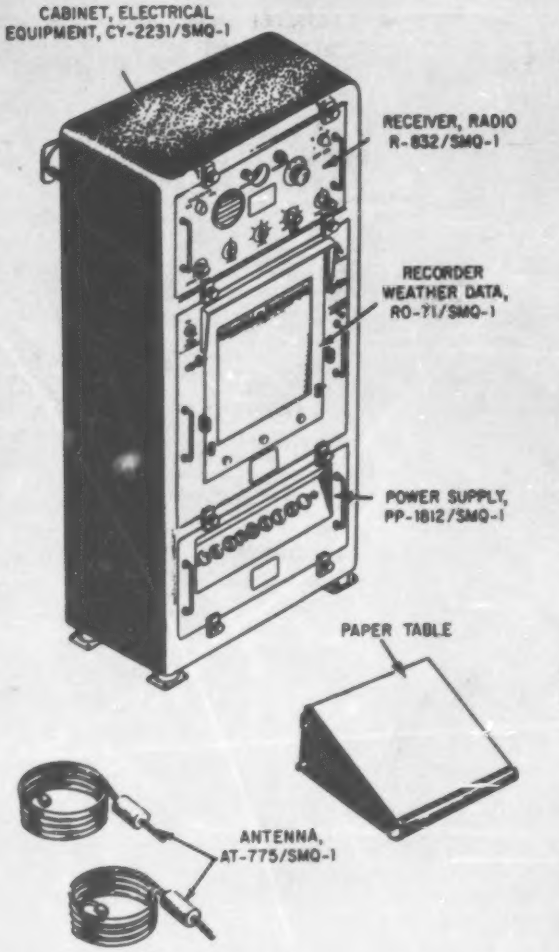

CABINET, ELECTRICAL EQUIPMENT, CY-2231/SMQ-1
RECEIVER, RADIO R-832/SMQ-1
RECORDER WEATHER DATA, RO-71/SMQ-1
POWER SUPPLY, PP-1812/SMQ-1
PAPER TABLE
ANTENNA, AT-775/SMQ-1
209.150

Figure 9-3.—Radiosonde Receptor AN/SMQ-1 ( ).

with which a computer can process and produce weather information is of little value if the product cannot reach the user on a real-time basis. This requires equipment that can receive and transmit data at a high rate of speed. This equipment and the system utilizing this equipment are discussed in the following paragraphs.

NAVAL ENVIRONMENTAL DATA NETWORK (NEDN)

The Naval Environmental Data Network (NEDN) is the primary computerized network for disseminating meteorological and oceanographic products of the Naval Weather Service. The system consist of all the Naval Weather Service computers linked together via high speed telephone circuits. The network extends to each of the four FLEWEACENs—Guam, Pearl Harbor, Norfolk, and Rota, and to FLEWEAFAC Suitland. FLENUMWEACEN Monterey, CA, with the greatest computer power, is the hub of this network and generates all the basic computer environmental analyses and forecasts distributed via the NEDN.

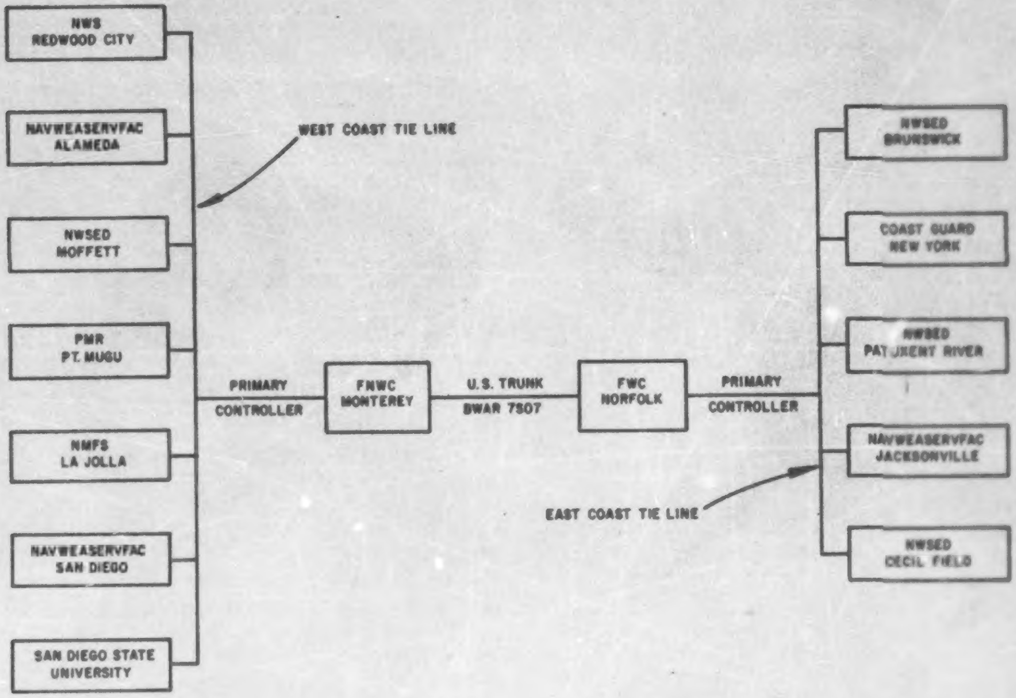
There are two circuits in CONUS called Tielines. These circuits parallel each coast, with the East Coast Tieline being operated by FLEWEACEN Norfolk, and the West Coast Tieline by FLENUMWEACEN Monterey. These tielines connect stations with their respective monitor stations as indicated in figure 9-4. Most of the raw data observations used by FLENUMWEACEN Monterey are received from the Automated Weather Network (AWN), which is the Air Force counterpart of the NEDN, via high speed circuits.

Major changes are occuring in computer equipment and therefore will not be discussed in great detail. The Naval Environmental Display Station (NEDS) is being introduced at NEDN and tieline activities. The introduction of NEDS-1, and others in the family of NEDS equipment, is leading to the removal of current Automatic Data Processing (ADP) equipment at the FLEWEACENs, and the elimination of the requirement for the Tieline as it now exists.

Collect and Transmit (CAT) Unit

The CAT unit is an electronic interface between high speed data transmission lines and a standard teletype. All stations on the tieline are issued a CAT unit such as that shown in figure 9-5.

The system is composed of an electronic controller, a miniature read/write magnetic tape handler with selectable endless tape loop cartridges, teletype input/output relays, power supplies, and a control panel. The tape cartridges are available in 3-, 6-, 9-, 12-, and 15-minute


NWS
REDWOOD CITY
NAVWEASERVFAC
ALAMEDA
NWSED
MOFFETT
PMR
PT. MUGU
NMFS
LA JOLLA
NAVWEASERVFAC
SAN DIEGO
SAN DIEGO STATE
UNIVERSITY
WEST COAST TIE LINE
PRIMARY
CONTROLLER
FNWC
MONTEREY
U.S. TRUNK
BWAR 7507
FWC
NORFOLK
PRIMARY
CONTROLLER
NWSED
BRUNSWICK
COAST GUARD
NEW YORK
NWSED
PATUXENT RIVER
NAVWEASERVFAC
JACKSONVILLE
EAST COAST TIE LINE
NWSED
CECIL FIELD

209.433

Figure 9-4.—East and West Coast Tielines.

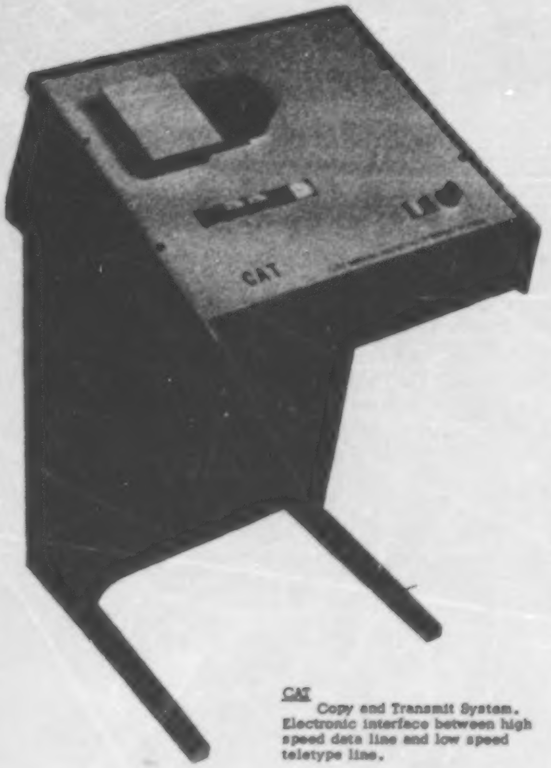
increments. A 70-second tape cartridge is also available for testing purposes.

The 3- or 6-minute tapes are most frequently used since, at 3,000 words per minute, this tape will receive most messages likely to be sent. Tapes can always be changed to either longer or shorter tapes as desired or when requested. Play back to a teletypewriter can be accomplished at speeds of 60, 75, or 100 words per minute as selected on the CAT unit.

The general application of the CAT unit is to accept digital data by monitoring teletype lines and to compactly store this data on a continuous loop magnetic tape cartridge as mentioned previously. Data stored on tape may be transmitted at much higher rates via telephone facilities or simply retransmitted over teletype lines at a time more convenient for operation. In a similar manner, data may be received from telephone facilities at a lower rate, permitting a page printout of hard copy or retransmittal at higher rates via telephone facilities. The modes described may be manually selected or, in an automatic mode, the telephone receive mode followed by a teletype transmit mode may be continually cycled as data presents itself.

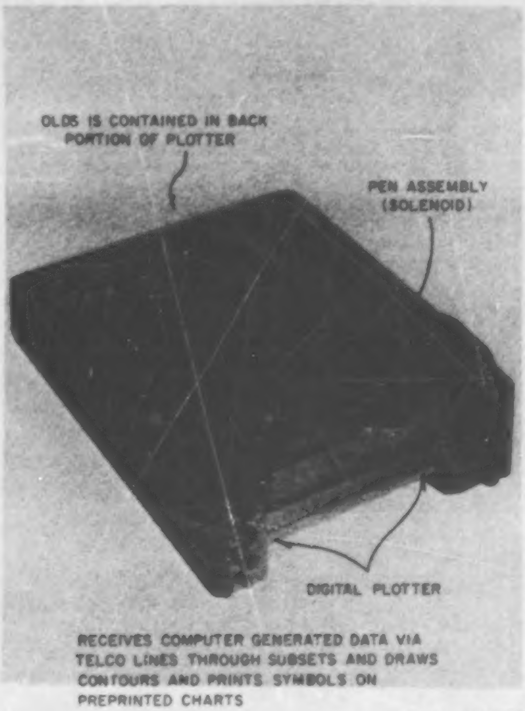
On-Line Display System (OLDS)

The OLDS logic unit is an electronic unit within the plotter consisting of several "cards" upon which are mounted components, such as transistors and resistors. It serves to transfer the incoming data into data which can be used by the plotter in making maps. The driver portion



CAT
Copy and Transmit System.
Electronic interface between high speed data line and low speed teletype line.

209.349
Figure 9-5.—NEDN Collect and Transmit Unit (CAT).


OLDS IS CONTAINED IN BACK PORTION OF PLOTTER
PEN ASSEMBLY (SOLENOID)
DIGITAL PLOTTER
RECEIVES COMPUTER GENERATED DATA VIA TELCO LINES THROUGH SUBSETS AND DRAWS CONTOURS AND PRINTS SYMBOLS ON PREPRINTED CHARTS

209.346
Figure 9-6.—NEDN On-Line Display System (OLDS).

of the plotter reveives the parallel data from the OLDS and produces maps through the operation of the pen up/pen down, drum up/drum down, and carriage right/carriage left functions.

Once the plotter has received the information from the OLDS unit, it will rapidly draw lines on the chart roll with a series of movements. The paper roll will move 0.01 inch per step, while the pen will move only from side to side or up and down.

The CALCOMP digital plotter consists of a drum type plotter and an electronic controller (OLDS logic unit) mounted on a single bedplate. (See fig. 9-6.)

Data Systems Technicians (DS) and/or civilian technicians are normally assigned to NEDN activities solely to maintain the computers and associated equipment. It is not, and should not be, the function of the Aerographer's Mate to carry out maintenance on this type equipment.

NAVAL ENVIRONMENTAL DISPLAY STATION (NEDS)

The NEDS is a transmission, storage, display and printout unit. It consists of a mini computer with storage capability, a television monitor display, a high speed teletype printer and a hard copy plotter. It will replace previous Automatic Data Processing equipment at NEDN activities and will eventually replace facsimile equipment at other Naval Weather Service Activities. A NEDS system is being developed for shipboard use.

FLENUMWEACEN Monterey transmits data from its computers to the storage unit at NEDS. The operator then may display any of the data at any time while it is in storage. Up to five charts may be displayed simultaneously, superimposed one over the other. He has the capability of producing a hard copy of displayed data.

The NEDS contains several significant advantages over all previous NEDN terminals including:

1. The ability to construct a chart from low speed lines. A typical chart should require less than 10 minutes at 100 wpm teletype rates.
2. A completely automated receiving terminal.
3. A soft and hard copy display capability.

Operation

The low speed data are received and entered into the teletype interface. The system can operate proportionally faster if higher data rates are available. The upper limit would be about 2400 bits per second, thereby producing a chart every 15 seconds. The interface accumulates the data bits to form characters. The assembled characters are then transferred to the mini computer. The mini computer examines the characters and takes the appropriate action to produce the desired output. Upon completion of the data transmission (typically 10 minutes), the complete chart is displayed on the TV monitor. A hard copy can be made in about 15 seconds on the electrostatic plotter. While the data are received, they may be placed on tape for later use if necessary.

NOTE: Complete details on the NEDS system are not available at this time. Refer to appropriate manuals and instructions as they become available.

CHAPTER 10

WATCH ROUTINES

Watchstanding is a task that is common to all weather offices. These watches may consist of a variety of functions, depending on the requirements and type of duty station to which you are assigned. This chapter will discuss the various procedures of watchstanding along with the procedures to be followed in performing many of the tasks that may be required during a watch.

PROCEDURES

The two procedures that will be covered are types of duties to be performed during the watch and guidelines for standing the watch.

TYPES OF DUTIES

There are many types of duties that may be performed during a watch. Many of the tasks are more important than others, but it should be remembered that all the tasks, whether major or minor, contribute to the operational efficiency of a properly run watch. A partial listing of these duties follows:

1. Observe, record, encode, and transmit surface observations.

2. Observe, record, encode, and transmit radar observations.

3. Operate various meteorological, oceanographic, and satellite equipment.

4. Observe, record, encode, and prepare for transmission, oceanographic observations.

5. Plot surface, upper air, and oceanographic charts.

6. Analyze surface, upper air, and oceanographic charts.

7. Decode and plot radioactive fallout reports.

8. Plot Skew-T Diagrams.

9. Display and file teletype and facsimile data.

10. Maintain office equipment.

11. Operate various communications equipment.

12. Perform administrative and supply functions.

All of these duties are individually covered in this chapter or have been previously covered in other chapters of this manual.

STANDING THE WATCH

The tasks you perform are a vital link to the economical and safe operation of your command, those served by your command, and the entire naval service. You perform a function which affects pilots, ship commanders, weapons delivery, missile launches, and many other activities. You must always remain alert, and perform your tasks professionally and with pride in doing your work to the best of your ability. You must be alert to any circumstance, whether it be a change in a weather element, an observation, or the status of operational equipment. You must be alert to advise those who need to know what that change is and when it will affect them. You must keep your forecaster and section leader up-to-date on changes occurring within your area of responsibility.

The following paragraphs of this chapter describe the procedures to be followed in performing the various tasks to which you may be assigned during your watch.

OBSERVATIONS

Accurate observing, recording, and transmitting of weather observations is one of the most important as well as one of the primary duties of the Aerographer's Mate.

Safety of life, property, and successful naval operations depend greatly on reliable forecasting. For this reason the observations upon which the forecasts are based must be as accurate as humanly possible.

Complete observations are the end result of a compilation of many small tasks or details. If these are done well, your observations will become invaluable to the forecaster. If observations are inaccurate they become a hinderance and are misleading. The accuracy and reliability of your observations are direct measures of your abilities and your dedication in performing your duties.

OBSERVATIONAL PROGRAMS AND CODE SYSTEMS

Observation programs fall into three general classes: those for weather units ashore, those for weather units afloat, and those for special weather units.

In general it can be said that weather units take as many observations as possible to fulfill the primary mission of the weather unit.

Individual commands may coordinate the observation program of two or more weather units. Such coordination conserves manpower without sacrifice of quality or quantity of service.

Nothing in the observing requirements limits any unit from taking such special or extra observations as operations may require.

When unusual or hazardous weather conditions develop, or upon indications of a severe storm, hurricane, or typhoon, an observation must be taken and immediately transmitted in accordance with applicable instructions.

Observational Program Ashore

Meteorological observations ashore are taken by Naval Weather Service units/activities in accordance with the Federal Meteorological Handbooks (FMH) and NAVWEASERVCOM detailed instructions and manuals.

Observational Program Afloat

Ships will take observations in accordance with NAVWEASERVCOMINST. 3140.1( ), which outlines the minimum requirements, and with the Federal Meteorological Handbooks and other directives. Ships with non-meteorological personnel aboard will utilize NAVWEASERVCOMINST 3144.1( ) in taking weather observations for transmission. All Navy ships at sea are required to take regular observations, but where ships are steaming in company or in close proximity (within 10 miles), the appropriate officer in command may designate one ship to take observations for the entire group. Ships in port are required to continue regular observing and reporting unless there is a nearby U.S. manned weather reporting station meeting the support requirements of the ship or group. In-port weather observing and reporting may be assigned to a guard weather ship at the discretion of the Senior Officer Present Afloat (SOPA). If this is done, the weather logs of all the exempted ships will bear a notation of the guard ship's name and the effective dates and times.

Observational Program of Special Weather Units

The observational program of a special unit ashore or afloat is determined by the command under which it operates. Although the specific requirements which create the need for a special unit govern the type of observational program carried out, every effort is made, in addition to meeting the special requirements, to carry out a standard observational program appropriate to the size and instrumentation of the unit. Special units sent to areas where data for climatological purposes are scarce or nonexistent should exploit each such opportunity to obtain valuable weather data.

Code Systems

Meteorological codes are international in scope and use. Basically, all the codes are the same the world over. They have been devised and agreed upon by the World Meteorological Organization (WMO). This organization is an affiliate of the United Nations, and its function is primarily to coordinate meteorological matters between the members.

Much standardization in meteorological matters—including meteorological codes—has been achieved. However, there are some regional or national exceptions to the general rules. For this reason, meteorological codes are defined in terms of the WMO regions. Within the WMO regions there are, in addition, also national differences. The WMO regions are as follows:

WMO Region I—Africa.
WMO Region II—Asia.
WMO Region III—South America.
WMO Region IV—North and Central America.
WMO Region V—Southwest Pacific.
WMO Region VI—Europe.
WMO Region IX—German Democratic Republic (East Germany).

Codes are the lifeblood of meteorological work; without them there could not be a system of observing and disseminating weather information as it exists. Codes permit the translation of a wealth of meteorological and oceanographic information into concise and comprehensive reports consisting of numbers and, in some instances, contractions. Moreover, codes break the language barrier and make possible international cooperation in the area of meteorology and its associated services.

Codes are also the elements with which Aerographer's Mates 3 and 2 come in daily contact. A great responsibility is placed upon you when entrusted to encode or decode meteorological and oceanographic information. You can and should accept this responsibility by learning and knowing the meteorological and oceanographic codes well. To accomplish this task you must study the following references:

1. International Meteorological Codes (Year) and Worldwide Synoptic Broadcasts, NAVAIR 50-1P-11 (hereinafter referred to as the Codes Manual).

2. The appropriate Federal Meteorological Handbooks (FMH) pertaining to codes.

Contractions

The sheer bulk of data required for a clear presentation of environmental conditions necessitates the use of contractions in order to reduce the length of messages. Contractions are used in observations to facilitate the reporting of all significant phenomena.

Some examples of contractions will be seen in this chapter; many more will be found in FMH No. 1.

SURFACE OBSERVATIONS

This section of the chapter deals with types of surface observations (aviation and synoptic) that are most commonly used in meteorology, along with some of the methods used to prepare the observations for coding. Observations are recorded on meteorological form MF1-10 at shore stations and NWSC form 3140/8 at sea, using the instructions contained in FMH No. 1.

Aviation weather observations are classified according to their purpose. The information included in each type of observation depends on the time of the observation, and the operating conditions and procedures of the reporting station.

Record Observations

Record observations are taken at scheduled hourly intervals. The record observation is a complete observation and contains the information for the following weather elements: ceilings; sky; visibility; weather; obstruction to vision; sea level pressure; temperature; dew point; wind direction, speed, and character; altimeter setting; and appropriate entries in the remarks column.

The entry in column 1 of MF1-10 and NWSC form 3140/8 for a Record observation is "R".

Special Observations

A Special observation is taken to report significant changes in weather elements. Special observations normally include the following elements: ceiling, sky condition, visibility, weather phenomena, wind and wind shifts, altimeter setting, and remarks. A Special observation for a tornado, waterspout, funnel cloud, or runway conditions may be reported as a single element special. When a Special observation coincides with a record observation, all elements required for the Record observation are observed, logged, and transmitted.

The proper entry in column 1 of MF1-10 and NWSC form 3140/8 for a Special observation is "S"; when the time coincides with a Record observation the proper entry is "RS".

Special observations are taken in accordance with the instructions contained in FMH No. 1.

Local Observations

Local observations may be taken and recorded at any weather observing station, for any meteorological situation which is established locally or, in the opinion of the observer, is significant to Local operations. A Local observation, however, must be taken and recorded immediately following notification of an Aircraft Mishap (other than an inflight emergency) unless there has been an intervening R or S observation. Upon notification of an inflight emergency, intensify the weather watch, taking and disseminating weather data as necessary to ensure maximum support to the aircraft in distress. If the end result is an aircraft accident or incident, take a Local observation, including all elements normally included in an R observation with the exception of sea level pressure. Include any other data deemed material to the accident/incident in the remarks column of MF1-10 and NWSC form 3140/8. Include the remark "ACFT MISHAP" in parentheses, but do not transmit this remark if the observation is disseminated.

Preparation of Forms

Enter observations legibly and in chronological order, restricting data as far as possible to the columns appropriate to them as indicated by the column headings. Ditto marks must not be used. Use a black lead drawing pencil, grade 2 or 2H, employing sufficient pressure to ensure legible copies and ample contrast for photographic reproduction. Test the impression by holding the completed form at arm's length in normal light. If all entries are easily read and completely legible, the impression is satisfactory. Numbers, symbols, and letters must be of such size as to fill three-quarters of the vertical space between lines.

Prepare MF1-10 in duplicate, at least. Unless otherwise specified, start a new page every day with the first observation having an ascribed time that is both later than 0000 LST and later than the ascribed time of the observation having a standard (reference) time of 0000 LST. Use additional pages as required. Aboard Navy ships, an NWSC form 3140/8 is prepared in duplicate, and a new NWSC form 3140/8 is started daily at midnight Greenwich mean time.

MISSING DATA.—Enter "M" in individual columns to indicate that data normally entered are missing EXCEPT that "/" is entered in 3- and 6-hourly code groups, in column 13. Explain briefly the necessity for "M" or "/" entries in block 90.

PARENTHESES.—Data entered in parentheses are for statistical purposes only and are not to be transmitted.

LATE OBSERVATIONS.—When an observation has been taken late and no appreciable changes have occurred since the scheduled time, enter the entire observation in black pencil and enter "NIL" in Col. 13. When conditions have changed appreciably since the scheduled time, estimate the conditions probable at the observation time, using recording instruments wherever possible, and enter the observation in red pencil. The observation is not transmitted but may be used for computation of sums and averages.

CORRECTIONS.—Enter corrected data on MF1-10 and NWSC form 3140/8 as follows:

1. Error discovered before report is disseminated, locally or longline—either erase the erroneous data from all copies and record corrected data, or draw a line through the erroneous data and enter corrections in the appropriate blocks on the next line or in col. 13, appropriately identified.

2. Error discovered after report is disseminated, either locally or longline—draw a red line through the erroneous entry and enter correction in red above it on all copies. If insufficient space is available, enter correction in red, appropriately identified in column 13; e.g., SLPRES 196, DWPNT 57, ALSTG 969, etc.

If the correction is transmitted over longline teletypewriter circuits, enter "COR" in red in column 13, followed by either the time (GMT) the report is delivered to communications personnel, or the time (GMT) the observer transmits the report. When the correction is only disseminated locally, enter the time (GMT) the report was disseminated following "COR."

WEATHER OBSERVATIONS DURING RADIO SILENCE.—The taking and recording of weather observations are continued for local operational and climatological uses regardless of conditions of radio silence; however the taking of radiosonde and other upper air observations involving airborne electronic transmissions is governed by the specific condition of radio silence in effect at the time.

Attention is invited to the instructions in NWP 16 ( ) concerning transmission of weather observations during periods of radio silence.

VERIFICATION OF OBSERVATIONS.—Of the several services provided by naval weather units, the taking of observations is a basic and most exacting one. Observational accuracy should not be taken for granted. Constant vigilance and care on the part of the observing personnel, with close supervision by the weather officer, are required to ensure that the weather elements are accurately observed, evaluated, and correctly entered on recording and coding forms. A recommended method for eliminating error in the observational entries is to have them checked by a second observer each watch or each day.

Other Entries on MF1-10

The major elements such as pressure, wind, temperature, precipitation, clouds, and visibility and their entries on MF1-10 were discussed in previous chapters of this manual. What remains to be covered are heading, time (Col. 2), weather elements and obstructions to vision (Col. 5), supplementary data (Col. 13), observer's initials (Col. 15), time (Col. 43), and other remarks, notes, and miscellaneous phenomena (Col. 90).

HEADING.—Enter in the spaces provided across the top of MF1-10 the sunrise/sunset times from monthly tabulations; station elevation; time correction factor for LST to GMT; degrees correction from magnetic to true; the day, month and year; and the station number, name, and state or country.

TIME (COL. 2).—The actual time the last element of the observation is observed and evaluated for observations taken for an aircraft mishap and for a Record observation. On Specials and Locals, other than observations taken for an aircraft mishap, the actual time of observation is the time the event requiring the observation is observed. Entries are in local standard time (LST) to the nearest minute in terms of the 24-hour clock. Insofar as possible, elements having the greatest rate of change should be evaluated last. When conditions are stable, evaluate elements outdoors first, then elements indoors with pressure last. The individual elements should, as closely as possible, reflect existing conditions at the actual time of observation. Unless otherwise specified, they must be within 15 minutes of the actual time of observation for Special and Local observations or the standard time of observations for Record and Record Special observations.

WEATHER ELEMENTS AND OBSTRUCTIONS TO VISION (COL. 5).—Atmospheric phenomena considered as weather elements of an observation are tornadoes waterspouts, funnel clouds, thunderstorms, and precipitation in any form. Hydrometeors (other than precipitation) and lithometeors are termed obstructions to vision. Electrometeors and photometeors, such as lightning, rainbows, halos, coronas, and auroras, are also observed. Observations of these phenomena, except for determining intensity of precipitation, are taken without the use of instruments and from as many points as necessary to view the entire horizon.

A definition and an explanation of the above elements are contained in chapter 15 of this training manual.

Enter weather and obstructions to vision in column 5, using only authorized weather symbols as shown in table 10-1. Determine the intensity of precipitation, using tables 10-2 through 10-6 as applicable. Precipitation is entered in this column only if actually occurring at the time of the observation.

The order of precedence for logging weather and obstructions to vision in column 5 are as follows: Tornado (funnel cloud or waterspout); thunderstorm; liquid precipitation, in order of decreasing intensity; freezing precipitation, in order of decreasing intensity; frozen preciptation, in order of decreasing intensity; and obstructions to vision, in order of decreasing predominance, if discernible.

Omit entry of obstructions to vision in column 5 whenever the visibility recorded in column 4 is 7 miles or more. If the visibility is less than 7 miles, weather or obstructions to vision must be reported either in column 5 if the phenomena are occurring at the station, or in column 13 if the visibility is reduced by phenomena not occurring at the station.

Table 10-1.—Symbols for weather elements and obstructions to vision for column 5 entries

TORNADO.	Tornado
WATERSPOUT	Waterspout
FUNNEL CLOUD	Funnel cloud
T+	Severe thunderstorm
T.	Thunderstorm
R.	Rain
RW	Rain showers
L.	Drizzle
ZR	Freezing rain
ZL	Freezing drizzle
IP	Ice pellets
IPW	Ice pellet showers
S.	Snow
SW	Snow showers
SP	Snow pellets
SG	Snow grains
IC	Ice crystals
A.	Hail
F.	Fog*
GF	Ground fog*
BS	Blowing snow*
BN	Blowing sand*
BD	Blowing dust*
IF	Ice fog*
H.	Haze*
K.	Smoke*
D.	Dust*
BY	Blowing spray*

[1] Suffix + to precipitation symbol to indicate heavy intensity and for light intensity. The absence of an intensity symbol indicates moderate intensity. No suffix is attached to "A", for hail or "IC" for ice crystals regardless of intensity or to any obstruction to vision symbols. "T" used alone indicates moderate intensity or less and lightning (LTG) is entered in column 13 as a mandatory remark.

*-Denotes Obstructions to vision.

NOTE: Tornado, waterspout, and funnel cloud are always written out in full in column 5 and column 13.

Intensities of precipitation are determined by one of two methods. One method is the rate of accumulation. The other method is the degree to which the precipitation affects visibility.

Intensities of all forms of precipitation except snow and drizzle are determined by the rate of accumulation. Intensities of all forms of snow (snow, snow grains, and snow pellets) and drizzle, when they occur alone, are determined by the effect on visibility. When any form of snow or drizzle occurs in combination with one or more hydrometeors or lithometeors, the intensity of the precipitation is determined on the basis of the rate of accumulation. The term "hydrometeors" includes all atmospheric phenomena composed of liquid or solid forms of water. A lithometeor, on the other hand, is composed of solid dust or sand particles, or the ashy products of combustion.

At stations not having recording gages, determine the intensity of rain from the guides

Table 10-2.—Estimating intensity of precipitation (other than drizzle) on rate-of-fall basis

Light	Scattered drops or flakes that do not completely wet or cover an exposed surface, regardless of duration to 0.10 inch per hour; maximum 0.01 inch in 6 minutes.
Moderate	0.11 inch to 0.30 inch per hour; more than 0.01 inch to 0.03 inch in 6 minutes.
Heavy	More than 0.30 inch per hour; more than 0.03 inch in 6 minutes.

Table 10-3.—Estimating intensity of drizzle on rate-of-fall basis

Light	Scattered drops that do not completely wet an exposed surface, regardless of duration to 0.01 inch per hour
Moderate	More than 0.01 inch to 0.02 inch per hour.
Heavy	More than 0.02 inch per hour.

Table 10-4.—Intensity of drizzle or snow with visibility as criteria

Light	Visibility 5/8 statute mile or more.
Moderate	Visibility less than 5/8 statute mile but not less than 5/16 statute mile.
Heavy	Visibility less than 5/16 statute mile.

Table 10-5.—Estimating intensity of ice pellets

Light	Few pellets falling with little, if any, accumulation.
Moderate	Slow accumulation.
Heavy	Rapid accumulation.

Table 10-6.—Estimating the intensity of rain

Light	Scattered drops that do not completely wet an exposed surface, regardless of duration to a condition where individual drops are easily seen; slight spray is observed over pavements; puddles form slowly; sound on roofs ranges from slow pattering to gentle swishing; steady small streams may flow in gutters and downspouts.
Moderate	Individual drops are not clearly identifiable; spray is observable just above pavements and other hard surfaces, puddles form rapidly; downspouts on buildings seen 1/4 to 1/2 full; sound on roofs ranges from swishing to gentle roar.
Heavy	Rain seemingly falls in sheets; individual drops are not identifiable; heavy spray to height of several inches is observed over hard surfaces; downspouts run more than 1/2 full; visibility is greatly reduced; sound on roofs resembles roll of drums or distant roar.

indicated in table 10-6. Determine the intensity of drizzle or snow when neither is occurring simultaneously with other atmospheric obstruction to vision (smoke, fog, etc.) on the basis of table 10-4. When either drizzle or snow is occurring simultaneously with other atmospheric obstructions to vision (except precipitation), estimate the intensity of drizzle on the basis of criteria in table 10-3. Estimate the intensity of snow on the basis of experience with the relative apparent rate-of-fall or accumulation on a surface recently free of precipitation.

It is well to remember that when precipitation equals or exceeds 0.04 inch per hour, there is a strong presumption that the precipitation is rain.

Intensities of ice pellets may be estimated by using table 10-2, if recording or totalizing gages are available; otherwise, estimate the intensity in accordance with table 10-5.

When more than one form of precipitation is occurring simultaneously, the individual intensities are estimated on the basis of experience; the use of tables 10-3 through 10-6 and table 10-2 give the basis for estimating the intensity of precipitation (other than drizzle) on the rate of fall; and the apparent relative proportion of the precipitation forms, as observed during their fall, or upon impact upon surfaces recently free from precipitation.

REMARKS (COL. 13).—In column 13 are entered mandatory and optional remarks which may be warranted as a result of the occurrence of weather or obstructions to vision. Some of these phenomena may warrant a Special observation.

Among the items requiring mandatory remarks are the times of beginning, ending, location, and direction of motion of tornado, waterspout, funnel cloud, thunderstorm; the frequency, type, and direction of lightning.

Obstructions to vision also require certain mandatory remarks. For instance, when an obstruction to vision is increasing or decreasing in intensity, or not occurring at the station, it requires a mandatory remark.

Enter remarks in symbols or abbreviations whenever possible; otherwise, use plain language. Use remarks to report any operationally significant information not reported elsewhere. Significant remarks are not limited only to those specified elsewhere in the manual. It is therefore important that the observer report any condition which in his best judgment is operationally significant, even though there is no precedent for the report among the types of remarks for the various weather elements stipulated in FMH No. 1.

Many types of remarks were discussed in earlier chapters of this manual. Additional entries include coded 3- and 6-hourly additive data, runway visibility, freezing level data, runway conditions, pilot reports, and weather modification. The order of precedence for recording these remarks at Navy stations is as follows:

1. Runway visibility.
2. Surface based obscuring phenomena.
3. Surface or tower visibility.
4. Wind shifts.
5. Other remarks elaborating on preceding coded data.
6. 3- and 6-hourly additive data.
7. Freezing level data.
8. Runway conditions.
9. Weather modification.
10. Pilot reports of cloud bases and tops.

A discussion on these remarks would be too lengthy for inclusion in this manual. For greater detail and criteria for entry, refer to FMH No. 1.

OBSERVER'S INITIALS (COL. 15).—Enter the initials of the certified observer responsible for the observation.

TIME (COL. 42).—Enter the beginning time of the first 6-hourly observation scheduled after 0000 LST in the block captioned MID TO. In the following four blocks, enter the beginning time of each 6-hourly observation. In the time zone where midnight LST corresponds to the time of a 6-hourly observation, omit all entries on the lines marked MID TO and MID. Make all entries in four figures to the nearest minute LST.

NUMBER (COL. 43).—This column is numbered from 1 through 4. The significance of this column is that an observer can tell at a glance the number of each 6-hourly observation taken during an LST day.

REMARKS, NOTES, AND MISCELLANEOUS PHENOMENA (COL. 90).—In this column, record all data considered significant, but not recorded elsewhere. All times of occurrence will be in LST unless otherwise specified. Some of the possible entries are as follows:

1. Conditions which affect the accuracy of recorded data.
2. Outages, changes in instruments, reasons for change, and times of change or outage.
3. Reasons for omission of mandatory data entries.
4. Time checks of station clock if not indicated elsewhere.
5. Change in hours of station operation, effective dates if temporary, or date if change is permanent.
6. Miscellaneous items, such as aircraft accident data.
7. Hailstorm information.
8. Harbor ice information.

Others Entries on NWSC Form 3140/8

As with MF1-10, the major elements were discussed in previous chapters; however, there are many other entries made on NWSC form 3140/8 that are not similar to MF1-10. The following paragraphs will approach marine observations by discussing these various differences.

POSITION.—Enter coded digits in the symbolic form Q_cLL111. These symbols have the following meaning:

Q_c—Quadrant of the globe in accordance with the table provided in FMH No. 2, Synoptic Code.

LL—Latitude to the nearest whole degree (e.g., enter 8° 22' as 08).

111—Longitude to the nearest whole degree, omitting the hundreds digit (e.g., enter 145°36' as 146).

The symbol "Q_c" is common to many meteorological codes utilizing latitude and longitude to locate a station or a meteorological element.

COURSE.—Enter the true compass course to the nearest whole degree. Enter a dash when the ship is not underway.

SHIP'S SPEED.—Enter the ship's speed to the nearest whole knot. Enter a dash when the ship is not underway.

TIME.—Enter the time (24-hour clock) to 4 figures GMT. Actual times are used for all observations (i.e., the time the last entry is made is considered the completion time of the observation).

SEA WATER TEMPERATURE.—Entered to tenths of a degree Celsius.

WAVE ENTRIES.—Only one wave system will be reported unless the height, direction, and period of a second system are clearly defined. Under normal circumstances, an experienced observer may not be able to define more than one wave train. In general, waves differing by 30° or more in direction or having a period difference of 4 seconds or more will be considered as separate wave trains. All wave data will be with respect to large, well-formed waves. The lower, poorly formed waves are disregarded.

Period.—Enter the time in whole seconds between the passage of two successive crests of well-formed waves past a fixed point.

Height.—Average vertical distance in feet between the wave crest and the adjacent trough is wave height. Whenever possible, obtain this distance by observing the waves near the side of another ship, and estimate their height with respect to known dimensions of the ship. For example, if the height of the bridge above the waterline is 28 feet and the wave crest reaches a quarter of this distance, the wave height is 7 feet. If another ship is not available, take the observations at a time when roll and pitch are slight and from a point amidships and near the centerline.

Sea Waves.—Sea waves are generated by local winds. Enter period and height of waves, coded as a 4-figure group ($P_WP_WH_WH_W$); period to the nearest second as the first two figures, e.g., 07 for 7 seconds; height to the nearest foot as the last two figures, e.g., 03 for 3 feet.

Swell Waves.—Swell waves are of two types:

1. Waves generated at some great distance from the ship.

2. The remains of locally generated waves after the local wind is no longer in evidence.

Swell wave information is entered in the following order; direction from which the waves are coming in tens of degrees with reference to true north and period and height in the same manner as sea waves.

SYNOPTIC OBSERVATION.—Naval Weather Service personnel utilize these columns to record synoptic observations and to prepare weather messages for transmission as required by NAVWEASERVCOMINST 3140.1( ).

Entries made in these columns are made in accordance with instructions contained in the latest revision to FMH No. 1. Coding instructions are contained in FMH No. 2, Synoptic Code.

DRY, WET, AND ICE.—Data in these columns are entered at synoptic times only, but are not transmitted.

Dry.—Enter the dry-bulb temperature to the nearest 1/10 of a degree Celsius.

Wet.—Enter the wet-bulb temperature to the nearest 1/10 of a degree Celsius.

Ice.—Enter a check in this column if ice is on the wick of the wet-bulb thermometer.

REMARKS, NOTES AND MISCELLANEOUS PHENOMENA.—Enter the time of sunrise and sunset, GMT, in the appropriate spaces. Other pertinent data, such as significant cloud groups, special phenomena groups, and other remarks or notes should be entered in this column.

WEATHER AND OBSTRUCTIONS TO VISION.—Enter the times (in GMT) of beginning and ending, the type and intensity, and the latitude and longitude (to the nearest whole degree) of weather and obstructions to vision. The specifications for the entries are the same as for the entries on MF1-10.

Code Forms

Other than the coded aviation hourlies, there are various other code forms with which the Aerographer's Mate must be familiar. The following paragraphs will briefly describe some of the more frequently encountered code forms. For a more detailed description, refer to the Codes Manual.

SYNOP—SURFACE REPORT FROM LAND STATION (FM 11.( )).—The word "synoptic" means, in general, pertaining to or affording an overall view. Synoptic observations are periodic (3-hourly or 6-hourly) observations which describe the overall weather conditions existing at the observing stations. The implication here is that they are complete weather observations. The synoptic code, therefore, is a code by which synoptic weather observations are communicated. Synoptic weather observations are, in turn, plotted on synoptic charts and then analyzed. The result is that a synoptic analysis or an overall view of the weather is obtained.

Synoptic observations are taken at periodic intervals the world over. Since the intervals coincide—that is, since they are taken at the same time all over the world—the plotted and analyzed synoptic charts afford a worldwide "snapshot" of the weather situation.

The symbolic form of message used by land stations for synoptic reports is as follows:

IIiii Nddff VVwwW PPPTT $N_hC_LhC_MC_H$ TdTdjajpjp (PoPoPoPo) (7RRjj) $(8N_sCh_sh_s)$ $(9S_pS_ps_ps_p)$

Groups in parentheses are optional.

METAR—AVIATION ROUTINE WEATHER REPORT (FM 15.( )).—This code is used primarily outside the United States for the same purpose the Aviation Weather (Airways) code is used within the United States. The information in the two codes is similar but the format is different. When you need specific information regarding it, refer to the Codes Manual.

SPECI—AVIATION SELECTED SPECIAL WEATHER REPORT (FM 16.( )).—The code form is the same as used for the METAR, except the term SPECI is used in the heading in place of METAR.

SHIP—SURFACE REPORT FROM SHIP IN FULL FORM (FM 21.( )).—The ship synoptic code, FM 21.( ) full form, is the basic ship synoptic code in use by fleet weather units and other U.S. ships (Navy or merchant). The contents of the code are very similar to those of the land station synoptic code; the only differences are those in reporting position, time, and certain information relating to the sea. The symbolic form of the ship synoptic code, full form, follows:

SHIP $99L_aL_aL_a$ $Q_cL_oL_oL_oL_o$ $YYGGi_w$
Nddff VVwwW PPPTT
$N_hC_LhC_MC_H$ D_sv_sapp
(7RRjj) $(8N_sCh_sh_s)$
$(9S_pS_ps_ps_p)$ $(0T_sT_sT_dT_d)$
$(1T_wT_wT_wt_T)$ $(2I_sE_sE_sR_s)$
$(3P_wP_wH_wH_w)$ $(d_wd_wP_wH_wH_w)$
ICE followed by plain language or by (c_2KD_ire)

SHIP—SURFACE REPORT FROM SHIP IN ABBREVIATED FORM (FM 22.( )).—Your use of this code will be only to decode and plot it. The first seven groups are identical with those of SHIP FM 21.( ). It is used by many merchant and foreign ships; it is not encoded by Navy ships.

SHRED—SURFACE REPORT FROM SHIP IN REDUCED FORM (FM 23.( )).—This code form is suitable for use by ships which do not have tested instruments and which are requested to report because of their location in sparse data areas. It is not used by Navy ships.

SPESH—SPECIAL WEATHER REPORT FROM SHIP (FM 26.( )).—This code is used by ships for reporting special weather conditions. Criteria for this report include specific changes in wind speed and/or direction, fog, precipitation, pressure, state of sea, and certain weather phenomena.

Forecast Codes

Along with surface observations, the Aerographer's Mate must be able to encode and decode the forecast conditions expected at his station, along the airways, and at other stations. The Navy terminal forecast code (PLATF) is discussed in detail, and a brief description on several of the other codes utilized in forecasts is covered in the following paragraphs.

TERMINAL FORECAST CODE (PLATF).—The "Plain Language Terminal Forecast Code" (PLATF) is the code form used by specified Naval Weather units for transmission coding of their terminal forecast.

The form and content of the code have been designed to include the necessary meteorological information for the safe operation and flight planning of aircraft landing and taking off from an air base. The code is based on the National Weather Service AVIATION FORECAST (TERMINAL) code and generally employs the same abbreviations and form used in the airways hourly observation code to be found in FMH No. 1, Surface Observations. The PLATF symbolic code form is as follows:

$G_1G_1G_2G_2$ h_sh_sNVVww ddff (Plain language) QNH

The time group indicates the 24-hour period of the terminal forecast.

The heights of cloud bases are indicated in hundreds of feet above the ground. Between the surface and 5,000 feet, heights are expressed to the nearest 100 feet; intervals of 1,000 feet from 5,000 feet to 25,000 feet, and intervals of 5,000 feet above 25,000 feet. The heights of cloud bases and cloud layers include surface based obscuring phenomena such as heavy snow, smoke, or fog which are expected to restrict the vertical visibility to less than the height of the base of the lowest cloud layer. (Refer to FMH No. 1 on reporting of obscured sky).

Cloud layers are written in ascending order of height separated by a space (scattered 1/10-5/10) (broken 6/10-9/10) and (overcast 10/10). Surface based obscuring phenomena, such as snow, smoke, or fog that is expected to reduce the vertical visibility to less than the height of the lowest layer of cloud is indicated by the symbol X and the height is the forecast vertical visibility. The term variable (V) is used in the remarks section when two or more cloud conditions are expected alternately. The predominant or most general cloud cover condition is included in the main text and the variable condition listed in the remarks. The base of the lowest layer of clouds forecast to have more than five-tenths coverage constitutes the ceiling. Where two or more layers of scattered clouds are forecast even though their cumulative amount is ten-tenths, the sky is considered as scattered. The rule of summation used in observations does not apply. The C identifier for ceiling is not used by Naval Weather Service forecasters.

The visibility term follows the cloud cover and is reported in miles or increments of miles. The visibility is forecast in the same values as prescribed in FMH No. 1. The term "variable" is not used in describing visibility in the general conditions group. The conditions that may be variable are described in remarks.

Standard letters or abbreviations contained in FMH No. 1 are used to indicate the state of weather or obstructions to vision and follow the visibility figure without a space. Intensities are denoted by a plus sign (+) for heavy, minus sign (-) for light, and a double minus for very light. Thunderstorms are carried as T. If the visibility is forecast to be 6 miles or less, weather or obstruction to vision must be included.

The surface wind group follows the terms for weather and obstructions to visibility and is forecast when the wind is expected to be 5 knots or more. If the wind is forecast less than 5 knots the abbreviation C for clam is used. Wind is separated by one space from the previous group. The wind is reported in the direction from which the wind is blowing measured clockwise from true north. Speed is forecast in knots. Wind direction is written in degrees to the nearest 10-degree increment. Gust winds are identified by the letter G following the wind speed.

Meteorological conditions considered to be of importance and not adequately covered in the general group are carried in the remarks section using authorized contractions and abbreviations where possible. Modifying remarks normally apply to visibility, sky cover, or winds. The following terms may apply in defining the changeable weather conditions:

1. Gradually (GRADU). This term indicates an improving or deteriorating condition during a specific period.

2. Temporary (TEMP). This term is used to modify the general forecast condition when changes are forecast to occur more than once or twice during the forecast period.

3. Occasional (OCNL). This term is used to modify a general condition with temporary changes occurring no more than once or twice during the forecast period to which the general condition applied. The changes in question should cover considerably less than half the total time.

4. Vicinity (VCNTY). This term refers to air mass type weather, such as showers,

thunderstorms, and patches of ground fog, which are expected to be widely scattered in the general area of the station. It is expected there is only a slight chance that they will affect the station itself. Lowest ceilings and visibilities expected in the phenomena in the vicinity are included in the forecast.

5. Frontal Passages (FROPA). Frontal passages are included in the forecast only if weather or a condition of operational significance is forecast. It is indicated by writing FROPA preceded by a 4-figure time group indicating the expected time of frontal passage and is followed by an adjusted forecast.

Additional plain language remarks may include the forecasted minimum altimeter setting expected during the forecast period.

A complete PLATF example follows:

```
KNPA 1212 15SCT 80 BKN 15 1910 SCT VBKN
     QHN 30.02 15Z 15BKN 80OVC 5H 2015
     10OVC 2TRW VCNTY QNH 29.98 19Z
     15OVC 3RF 2315 TEMP 8OVC IRF QNH
     29.96 0000Z CLD FROPA 20SCT 80BKN
     15 3215G25 QHN 30.01 GRADU 04Z-06Z
     CLR 15 3410 QHN 30.05
```

TAF—AERODROME FORECAST (FM 51.()).—The code name TAF is used as a prefix to the message indicating that it is an aerodrome forecast, but in case of a group of such forecasts, it is only used in the heading of the collective. The symbolic form of the TAF code is as follows:

TAF	CCCC	$G_1G_1G_2G_2$	$dddff/f_mf_m$	
	VVVV	ww	$N_sCCh_sh_sh_s$	
	or			
	CAVOK			
	$(0G_FG_FT_FT_F)$	$(6I_ch_ih_ih_it_L)$	$(5Bh_Bh_Bh_Bt_L)$	$9i_3nnn$

Groups or elements with an indicator figure may, unless otherwise specified, be omitted from a particular message whenever the elements specified in the group are forecast not to occur, or are not required. Groups may have to be repeated in accordance with the detailed instructions for each group.

Obtain general coding instructions for this and the following forecast codes by referring to the Codes Manual.

ARFOR—AREA FORECAST FOR AVIATION (FM 53.( )).—The code name ARFOR is used as a prefix to the message indicating that it is an area forecast.

ROFOR—ROUTE FORECAST FOR AVIATION (FM 54.( )).—The code name ROFOR is used as a prefix to the message, indicating that it is a route forecast.

SATELLITE OBSERVATIONS

At most weather stations throughout the United States, satellite information is provided routinely by facsimile transmission of data previously received at satellite tracking centers. If, however, you are attached to an overseas station, or a ship, you will most likely be involved in obtaining your own satellite information.

In chapter 6 of this manual the various types of satellite sensing and tracking equipment were described. This section will discuss satellite applications and expansion, terminology, satellite tracking information, and instructions for gridding the obtained pictures. These procedures provide the forecaster with an invaluable means of obtaining meteorological information. The data received by this means is used to supplement the more conventional methods of observed data. It will, in many cases, be the only method available to observe developing storms and their associated cloud systems.

Satellite Terminology

In any field of science, there are numerous terms, definitions, and contractions that need to be understood. Without this information it is extremely difficult to understand the operational procedures and functions in the field of endeavor. The list of terms, definitions, and contractions presented in the following paragraphs is not meant to be a complete glossary. For more complete coverage you must refer to the various technical manuals pertaining to satellites. Figures 10-1 and 10-2 are diagrammatic illustrations to aid in understanding some of the terms described below.

APT—APT stands for Automatic Picture Transmission. It is a weather satellite system that is designed to sense and transmit data in the blind.

APT TERMINAL GROUND EQUIPMENT—The receiving and recording ground station that is designed to receive and print the pictures that are transmitted by a satellite equipped with APT capabilities.

APOGEE—The point in orbit at which the satellite is farthest from the center of the earth. (See fig. 10-1 (D).)

ARGUMENT OF SATELLITE—The geocentric angle of a satellite measured in its orbital plane from its ascending node in the direction the satellite is traveling. (Take a basketball and place a mark on it at any point. Start around the basketball to any other point. Mark the two points, and measure the angle between lines drawn from these two points to the center of the basketball. This is the argument of satellite.)

ASCENDING NODE—The point at the equator at which the satellite in its orbital motion crosses from the Southern to the Northern Hemisphere, or the point at which the satellite crosses the equator going from south to north. This is the direction in which all satellites move at the time of the ascending node. (See fig. 10-1(E).)

ASCENDING NODE TIME—The time when the satellite passes the equator going from south to north, or passes the ascending node.

ATS—Applications Technology Satellite.

DEGRADATION—The lessening of picture image quality because of noise, rotation of the satellite, etc., or any optical, electronic, or mechanical distortions in the image forming system.

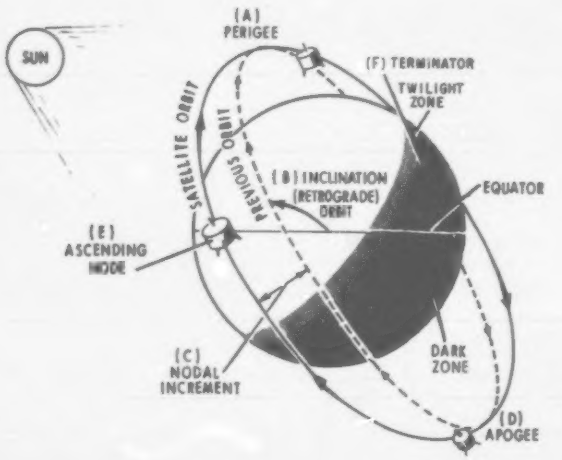


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Figure 10-1.—Diagrammatic drawing defining orbital satellite technology.

DESCENDING NODE—The south bound equator crossing of the satellite, or to put it another way, the halfway point in one orbit. (The descending node will be approximately 180 degrees of longitude from the ascending node.) The earth moves from under the satellite; if the earth did not move, the descending node would be exactly 180 degrees from the ascending node.

DISTORTION—An apparent warping and twisting of a picture image received from a satellite. This distortion has two causes—electronic and optical.

DMSP—Defense Meteorological Satellite Program.

EARTH-SYNCHRONOUS ORBIT—An orbit in which the motion of the satellite is synchronized with the motion of the earth so that the satellite will appear stationary in time and space.

ESSA—Environmental Survey Satellite.

GOES—Geostationary Operational Environmental Satellite.

HRPT—High Resolution Picture Transmission.

INCLINATION—The angle between the plane of the satellite orbit and the earth's equatorial plane. In other words, the angle at which the satellite crosses the earth on its ascending node, measured counterclockwise from the equator. An angle of less than 90 degrees is called a prograde orbit, and an angle of more than 90 degrees is called a retrograde orbit. Inclination of a retrograde orbit is expressed by 180 degrees minus the prograde inclination. Refer to figure 10-1(B) for an example of orbit inclination.

IR—An infrared sensor that measures radiated heat rather than reflected light.

NESS—National Environmental Satellite Service.

NOAA—National Oceanographic and Atmospheric Administration.

NODAL INCREMENT—Degrees of longitude between successive ascending nodes. (The earth moves out from under the satellite during the nodal period; the nodal increment is the amount of turning measured in degrees of longitude, that takes place during one nodal period.) (See fig. 10-1.)

NODAL PERIOD—The time elapsing between successive passages of the satellite through the ascending nodes.

ORBIT—One complete circling of the earth by a satellite from a reference point to the same reference point.

ORBIT NUMBER—Refers to a particular circuit beginning at the satellite's ascending node. The number from launch to the first ascending node is designated as ZERO.

PERIGEE—The point in orbit at which the satellite is closest to the center of the earth. (See fig. 10-1(A).)

POLAR ORBIT—An orbit in which the satellite would pass over both of the earth's poles.

PRINCIPAL POINT—The point on earth where the camera is focused at any time during the orbit. If the camera's vertical axis is perpendicular to the earth's surface, the principal point coincides with the subpoint. (See fig. 10-2(A).)

SMS—Synchronous Meteorological Satellite.

SR—Scanning Radiometer.

SUBPOINT—The point on earth directly below the satellite at any given time during its orbit. (See fig. 10-2(B).)

SUBPOINT TRACK—Projection of satellite orbit on a rotating earth. It is the satellite's projected path over the earth's surface with a moving earth. From information obtained from the subpoint track, the antenna can be pointed in the direction of the satellite. (See fig. 10-2(C).)

SUN TIME—The time of the day according to the sun. It has nothing to do with local time or Zulu time. 1200 sun time is the time that the sun is directly overhead. 1300 sun time is the time when the sun is exactly 15 degrees of longitude to the west of the longitude where it was at 1200.

SUN-SYNCHRONOUS ORBIT—An orbit in which the satellite will always pass over the equator at the same sun time on each of its orbits.

TERMINATOR—A line on the globe separating the daylight side of the globe from the nighttime side. (See fig. 10-1(F).)

TIME PAST ASCENDING NODE—The amount of time for a body in orbit to advance from the last ascending node to an arbitrary position.

TRACKING—Procedures for keeping the antenna pointed at the satellite as it moves through its orbit.

TRACKING OR PLOTTING BOARD—Polar projection diagram of the earth centered at either pole and extending to 30 degrees of latitude past the equator into the other hemisphere. The board has radials from the pole representing 1-degree intervals of longitude; each fifth radial is accentuated. Concentric circles on the projection represent latitudes.

TRACKING DIAGRAM—The tracking diagram was constructed to show azimuth and distance of the satellite from the station for a given subpoint position.

A different tracking diagram is provided for each 5-degree latitude belt. The diagram drawn for the latitude closest to that of the ground station should be used.

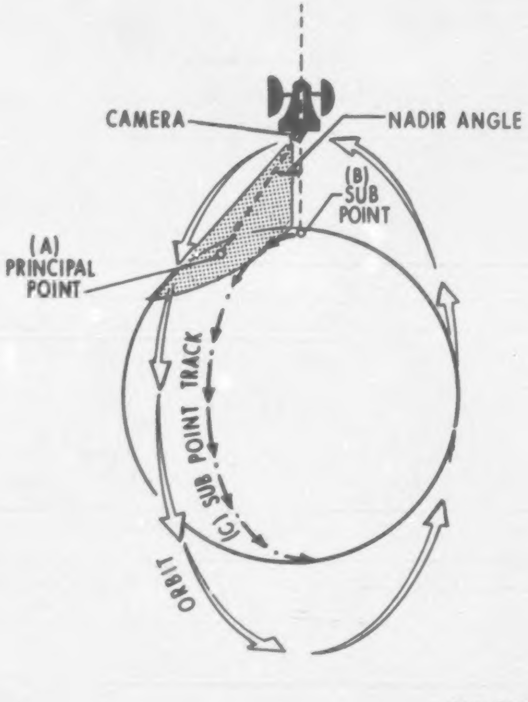

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Figure 10-2.—Diagrammatic drawing defining satellite tracking terminology.

TRACKING OVERLAY—This is a circular transparent disk which is centered at the pole on the tracking board. On this, the subpoint track of the satellite from which data will be acquired is plotted.

VHRR—Very High Resolution Radiometer.

VHR—Very High Resolution.

VISSR—Visible Infrared Spin Scan Radiometer.

VTPR—Vertical Temperature Profile Radiometer. A device which obtains data similar to the radiosonde.

WEFAX—Weather Facsimile as applied to satellite rebroadcast of ground prepared data.

Satellite Applications

Many areas of the earth have no weather observing stations or so few that serious weather disturbances arise and move, undetected, toward inhabited regions. This allows conditions to develop to the stage where adequate forecasting occurs too late to be really effective. In many instances, even the relatively dense continental network of stations is not adequate, particularly when disturbances move in from oceanic or arctic areas where weather observations are not available. The meteorological satellite provides a truly global means of observing a global phenomenon. This feature makes it an ideal meteorological observing platform providing real-time data.

A real-time data system is one which transmits data to a recipient continuously as it is acquired by the system instead of saving the data for readout at a later time. As used in this chapter, the term refers to the fact that the satellite transmits meteorological data to the ground receiving equipment as soon as it senses them instead of storing them on tape for later readout.

The most commonly used satellite real-time data system is the SR Scanning Radiometer which acquires and transmits data during both the daylight and dark portions of the orbit.

SR SYSTEM.—The SR system for real-time transmission consists of sensors that measure radiation in the visual and infrared regions of the spectrum. The reflected light and radiated temperature values are converted to electronic signals which are then converted to cloud-type pictures by the ground receiver.

As the spacecraft moves along its orbit, the radiometer scans the earth's surface from horizon to horizon, essentially perpendicular to the orbital track. The scan across the track is generated by a mirror continuously rotating (through 360 degrees) and reflecting energy to the sensor. Data as sensed are converted to electrical signals which are transmitted in real-time.

Satellite Expansion

The meteorological satellites are continuously becoming more versatile through the addition of new and improved detection devices, as in the case of the more improved radiometers. Other improvements include picture quality through improved technology, magnetic tape storage, and more advantageous orbital positions. These continue to provide advancement in the field of satellite expansion.

There are many other meteorological uses being developed along with research in other scientific fields. These research projects are described in many available NASA and NOAA papers and are too lengthy for discussion in this manual.

Meteorological satellites have come a long way since the launch of the first experimental TIROS satellite. The United States presently has satellites in operational use that are capable of transmitting meteorological information by direct readout to ground stations. These are the ITOS/NOAA, SMS/GOES, and the DMSP. A brief description of each of these satellite systems and their capabilities follows:

ITOS/NOAA.—These sun-synchronous satellites, which are in near polar orbit, carry three subsystems for acquiring data which is stored or transmitted in real-time to readout stations. These systems are the SR, VHRR, and VTPR, all of which operate both during the day and night. However, only the SR data is capable of being received by the worldwide low-cost network of ground receiving stations. Only a few elaborate and expensive stations are capable of receiving the VHRR and VTPR data.

SMS/GOES.—The current series of geostationary satellites for meteorological data acquisition and relay are capable of both WEFAX and VISSR imagery. The receipt of WEFAX can be accomplished by existing ground stations after a minor modification to the receiver, but the VISSR data requires extensive and complex equipment.

DMSP.—Within the Navy this satellite system uses an Air Force satellite in conjunction with the Navy tracking equipment, TMQ-29 (ashore) and SMQ-10 installation (shipboard). The DMSP routinely employs two polar orbiting satellites; both have visual and IR scanning radiometers. Direct real-time readout of regional data is provided to selected military locations around the world. Data for the entire globe is provided to the Air Force Global Weather Central, Offutt AFB, several times per day. This system was developed with the primary objective of providing maximum responsiveness to the military decision maker.

APT Predict Message

In order for Naval Weather Service personnel to utilize the facsimile picture for meteorological purposes, certain information must be furnished. Full utilization of the picture data depends upon acquiring a video signal transmitted by the satellite, geographically locating the picture center, orienting the picture into the correct geographical aspect, and extracting the meteorologically significant data.

In order to track the satellite and to locate, orient, and grid the facsimile picture, personnel operating the ground equipment require certain satellite predictive data; the APT daily predict message provides this required information.

The APT predict messages are provided routinely to Navy users in two different forms. One form is a daily teletype message, the other is the WEFAX message. Both messages contain identical information. The message contains all the necessary information required for tracking the satellite during normal operations.

The APT predict message contains a heading and four parts. For the convenience of the user, daylight and night portions of the message have been separated.

Part I contains information pertaining to the reference orbit, and to orbits four, eight, and twelve. Information contained in this part includes the time and location of the crossing at the Equator of the reference orbit, nodal period, nodal increment, and the time and place of the crossing of the Equator for the fourth, eighth, and twelfth orbits; these orbits are in relation to the day of the predict message.

Part II (day) contains the satellite's altitude and subpoint data at 2-minute intervals over the sunlit portion of the orbit north of the Equator.

Part II (night) contains the satellite's altitude and subpoint data at 2-minute intervals for the portion of the orbit which is in darkness north of the Equator.

Part III (day) contains the satellite's altitude and subpoint data at 2-minute intervals over the sunlit portion of the orbit south of the Equator.

Part III (night) contains the satellite's altitude and subpoint data at 2-minute intervals for the portion of the orbit in darkness south of the Equator.

Parts II and III provide data for plotting the subpoint track. The 2-minute intervals used are based on the ascending node of time and are given as minutes after or before this time.

Part IV is reserved for any remarks pertinent to the operation of the system, including the orbital elements of polar orbiting satellites. These elements will be updated periodically. In addition, messages concerning polar orbiting satellites contain the current scanning radiometer calibration temperatures.

The symbolic format of the APT predict message is contained in the NOAA direct transmission user's manual and other appropriate satellite manuals.

Tracking and Satellite Location

The task of keeping the receiver tuned and the antenna pointed at the satellite for receipt of the incoming data is referred to as "tracking."

For proper satellite tracking, the location of the satellite in relation to the ground equipment must be known for the entire period that the satellite is within range of the ground equipment. Depending on the satellite, it will first appear as it crosses either the southern or the northern horizon. From the time the satellite comes within the line of sight until it disappears over the opposite horizon, the antenna of the ground equipment must always be pointed at the satellite. In order to train the antenna on the satellite, the proper azimuth and elevation angles must be known.

The APT PREDICT MESSAGE discussed earlier in this chapter must be referred to for necessary tracking information.

In order to compute the required data for proper satellite tracking, weather service personnel must utilize an APT tracking board with a transparent orbital overlay and a tracking diagram. These were defined in the preceding terminology and described in chapter 6 of this manual.

For complete information on the procedures used for the postlaunch preliminary preparation of the tracking board, transparent orbital overlay, and tracking diagram, and for instructions in completing an APT tracking worksheet, refer to the NOAA Direct Transmission System Users Guide, or the applicable meteorological satellite manual. Some of the steps and procedures to be followed in preparation for receipt of the satellite transmission are as follows:

1. The appropriate tracking diagram is centered on the tracking board at the location of the ground station.

2. The reference subpoint track is plotted on the overlay.

3. The equatorial line is marked on the overlay with the ascending node location for the reference orbit and all other orbits 1 through 12.

4. The equatorial zone of acquisition is determined.

Proper satellite tracking preparation requires the use of the correct APT predict message and the determination of which orbits can be tracked.

When it has been determined which orbits can be tracked, an APT tracking worksheet for each orbit must then be prepared.

The satellite pictures received on the ground station's recorder are of no value to the weather forecaster unless the picture has been properly gridded. The term "gridding" refers to the process of drawing longitude and latitude lines on the received picture.

Recorders, which do the gridding internally, and provide a picture with latitude and longitude lines already on it, have replaced earlier models; consequently, the exacting task of manual gridding is seldom, if ever, required. Should manual gridding be required, refer to the User's Guide for detailed information.

SR Data and its Application

The scanning radiometer can sense reflected and radiant energy. This allows complete coverage throughout the entire orbit, over the dark areas of the earth as well as the daylight areas.

The SR infrared facsimile picture looks like a distorted television picture of clouds (fig. 10-3). Various shades of gray which appear in these pictures represent effective radiating temperatures, not variations in reflectivity of visible light. The radiating temperature of a body is affected by its radiative properties, as well as by its temperature. Water, ice, and various types of soil have widely varying radiative properties which affect the readings of infrared sensors. Since atmospheric temperature generally decreases with altitude, it is possible to make gross inferences about the heights of cloud tops from their temperatures shown by infrared. Only three classes of temperature (shades of gray) may be readily distinguished in the pictures:

1. White areas show the coldest temperatures and therefore represent high clouds or snow-covered areas.

2. Light gray areas represent moderate tropospheric temperatures and middle cloudiness. This usually means ceilings 7,000 to 12,000 feet and little or no precipitation. The lighter shade of gray may represent a height difference of as little as 3,000 ft between the tops of middle clouds and the tops of low clouds.

3. Dark gray areas show relatively warm tropospheric temperatures. However, low cloudiness with little vertical development, such as small cumulus, stratocumulus, stratus, and fog, are indistinguishable from background noise in the infrared pictures. The decision as to whether the dark gray area contains cumulus, stratocumulus, fog/stratus, or no cloud can be made easily from the VHRR pictures. On the other hand, the infrared can be used to make decisions about cloud top height that cannot be made from the VHRR pictures.

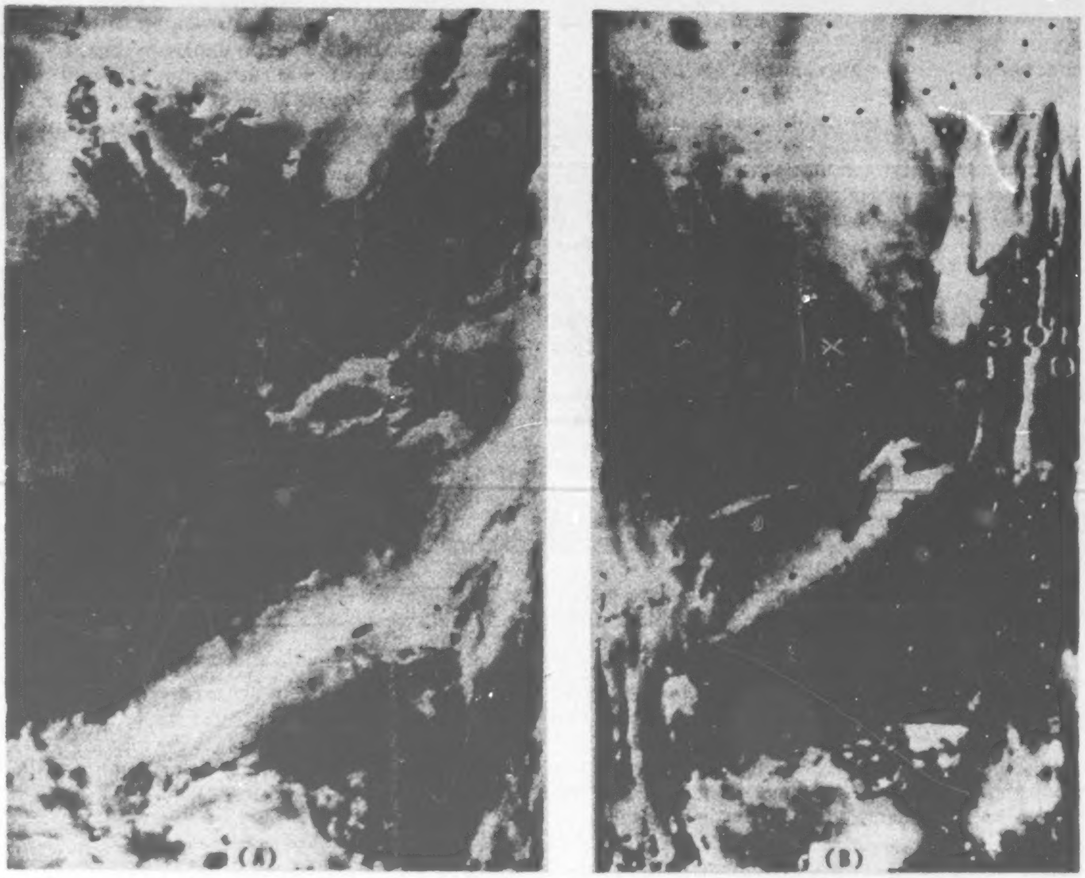

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Figure 10-3.—SR picture. (A) Daytime infrared view of Baja, California; (B) Nighttime infrared view of Baja, California.

RADAR OBSERVATIONS

Radar provides us with an excellent means of acquiring a detailed, continually updated presentation of precipitation and associated cloud patterns. It is for this reason that the Aerographer's Mate must be familiar with the principles involved and the format used in compiling radar weather observations.

Radar weather observations are available over designated teletype and facsimile networks. They provide valuable information to assist the forecaster in evaluating and forecasting some of the many aspects of observed weather such as the characteristics of fronts, thunderstorms, tropical cyclones, freezing levels, etc. However, the Aerographer's Mate should keep in mind that the radar data does not replace conventional observations but is an excellent supplement to them.

For optimum results it is necessary to keep continuously informed on the current weather situations which are related to the depicted radar data.

There are only a few Naval Weather Service units which actually transmit radar weather observations. However the data must be intelligently interpreted when received from other sources. For a detailed description of the principles and procedures of weather radar observations, refer to FMH No. 7, Weather Radar Observations.

OCEANOGRAPHIC OBSERVATIONS

Accurate sea condition observations are necessary if the forecaster is to be expected to provide accurate sea condition forecasts for operational use.

When a breeze comes up, the sea surface will instantaneously become covered with tiny ripples which form more or less regular arcs of long radius. They increase rapidly in height until they attain a maximum steepness where the pointed crests take on a smooth glassy appearance, indicating small breaking processes. As the wind continues to blow over the sea, it drags over the surface producing increasingly larger waves. The wind acts in a manner similar to a paddle rhythmically stroking the water. There is, however, one difference. The wind is constantly making small changes in direction and speed. The result is that the wind is acting like many different paddles stroking the sea in different directions and at different speeds. This produces many different wave trains in the sea, all with different directions, all with different periods, and all at the same given point in the ocean. Figure 10-4 illustrates this concept.

If all the different wave trains generated are considered to be sine waves with different heights, directions, and periods, the sum of the heights of the sine waves at a given instant is the mechanism that produces the irregular appearance of the sea. The various waves which comprise the sea surface are commonly referred to as either sea waves or swell waves.

Sea Waves

Sea waves are defined as the waves generated by local winds. If locally developed winds persist for sufficient time, they will cause sea waves to develop whose dimensions vary directly with the wind velocity. Waves can continue to grow only as long as they receive more energy from the wind than they lose due to turbulent mixing of the breaking sea.

It is important to keep in mind that sea waves are locally generated, and do not include "swell waves" for observational purposes. Swell waves are those waves moving into the area from some storm outside the local area.

There are a number of differences between sea waves and swell waves. An illustration of each type is shown in figures 10-5 and 10-6.

Description of Sea Conditions

Wave height is the height difference between the wave trough and its crest. Wave period is the time interval (in seconds) in which a wave repeats itself exactly; that is, the time between consecutive troughs, crests, or any specific corresponding points. The sea cannot be properly described by a single height and period because no single height and period is truly representative. There are many different heights and periods in the sea, and to describe it, it is more correct to give several heights and several periods which give a better idea of what is actually happening in the sea. For this reason the following terms are needed to properly describe the sea condition:

1. Average Wave Height.—The average height of ALL the waves.
2. Significant Wave Height.—The average height of the highest one-third of the waves.
3. One-Tenth Highest Waves.—The average height of the highest one-tenth of the waves.
4. Average Period. The average period of all the waves.
5. Lower Limit of Periods. The lowest (shortest) period found in a particular sea state.
6. Upper Limit of Periods. The highest (or longest) period found in a particular sea state.

Sea Condition Measurements

There have been a number of new developments regarding instruments for measuring temperature, pressure, density, etc., of the sea; however, to describe the physical characteristics of the sea surface as related to height, period, and direction of the sea, the observer must continue to use his experience while comparing the sea surface to some existing reference object. This means utilizing reference points such

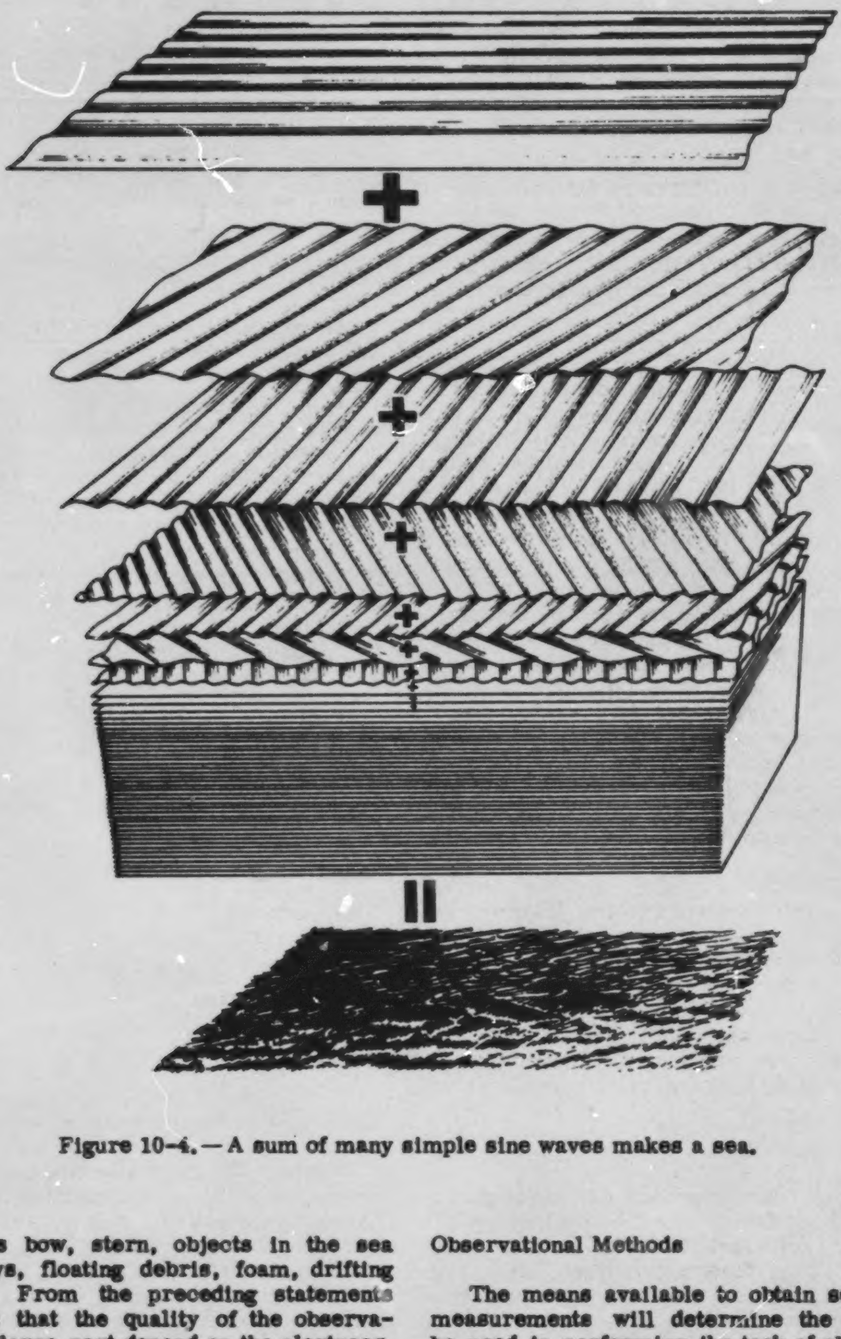

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Figure 10-4.—A sum of many simple sine waves makes a sea.

as the ship's bow, stern, objects in the sea such as buoys, floating debris, foam, drifting objects, etc. From the preceding statements it is obvious that the quality of the observations will in large part depend on the alertness, dedication, and experience of the observer.

Observational Methods

The means available to obtain sea condition measurements will determine the methods to be used in performing the task of observing and recording the sea condition.

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Figure 10-5.—Illustration of sea waves.

PERIOD OBSERVATIONS.—The term "period" used in this section refers to the time interval between successive crests. However, there is no such thing as a "period" in an ocean wave record, or in actual ocean waves, because the wave pattern never repeats itself. It should be possible, while watching the waves pass a fixed point, to start a stopwatch at the time that a given crest passes that point and stop it when the next crest goes by. The procedure gives a certain time interval. If enough of these values are recorded and tabulated, the result is a frequency distribution of the so-called periods.

The best place to observe the time intervals between successive crests of the wave system is from a high point on the ship, such as the deck above the bridge. Look one or two ship lengths ahead to windward. Pick out a mark; for example, a large foam patch, a clump of seaweed, or any other drifting object which is easily seen and at a relatively fixed point on the sea surface. Note the elapsed time in seconds between the moments when the mark is on the crest of the first and last well formed wave in the group. Count the number of wave crests that pass under the mark during the interval. Continue to evaluate the wave sets

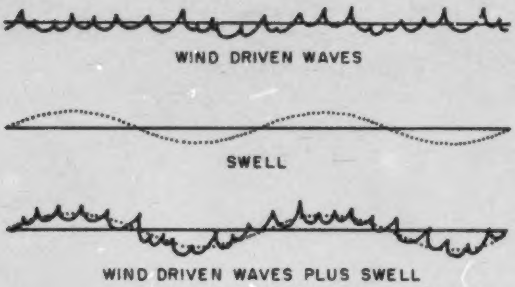

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Figure 10-6. — Swell and wind waves in combination.

until at least 15 waves have been determined. Divide the number of waves by the elapsed time to determine the wave period. Do not count the wave crest on which the timing of the mark is started.

OBSERVATION OF WAVE HEIGHTS. — The observation of wave heights from shipboard is complicated by the rolling and pitching of the ship, its rising and falling with the waves, and the presence of high local winds. Low waves tend to be underestimated; high waves, overestimated. The best estimate can be obtained by observing another ship in company. The height from trough to crest of a wave against her side can be estimated as a part of some known vertical distance. For example, a wave might be 1/4 of the bridge height of 28 feet, or 7 feet high.

Without the aid of another ship, you must make your observations at times and positions when your own ship's motions are as small as possible. Observations should be made amidships and near the center line. If possible, the ship should be heading into the waves. If not, choose a time when the rolling and pitching is at a minimum.

If waves are shorter than the ship, estimate the wave height by looking over the side — using as a yardstick the relative heights of known points along the side.

If waves are longer than the ship, wait until the ship is in the trough of a wave. By trial and error, move up and down on the superstructure until the wave crests are on a line with the horizon. Then the distance your eye is from the ship's water line is the height of the wave. If the ship is rolling, care should be taken to line up the wave crest with the horizon at the instant the ship is on an even keel otherwise the height estimate will be too large.

The heights of waves usually vary considerably. Observations should be made for approximately 5 minutes and mental estimates made of the higher waves in each wave system. If two observers are available, one can make the estimates and the other record the observed values. The wave height to be recorded is not that of the highest wave, nor the lowest, but the average of all the waves.

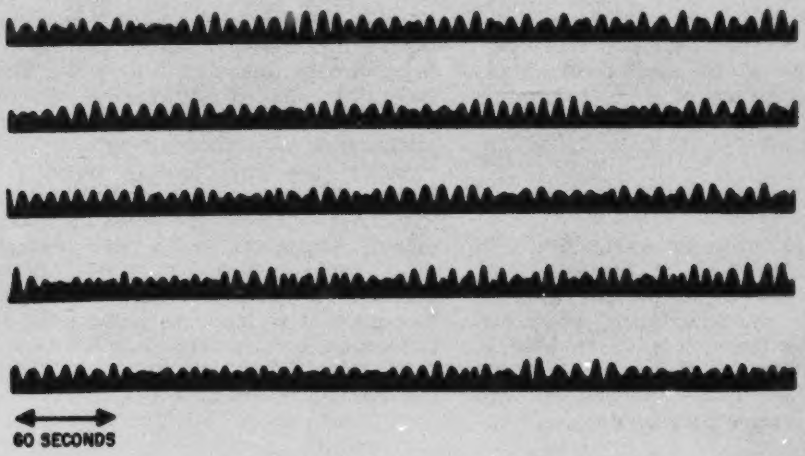
When both sea and swell or two systems of swell are present at the same time, observations will be more difficult. You should estimate the higher system of waves first, then repeat the process for the lower system.

Swell Observations

Swell waves may be defined as being sea waves which have traveled outside of their generating area.

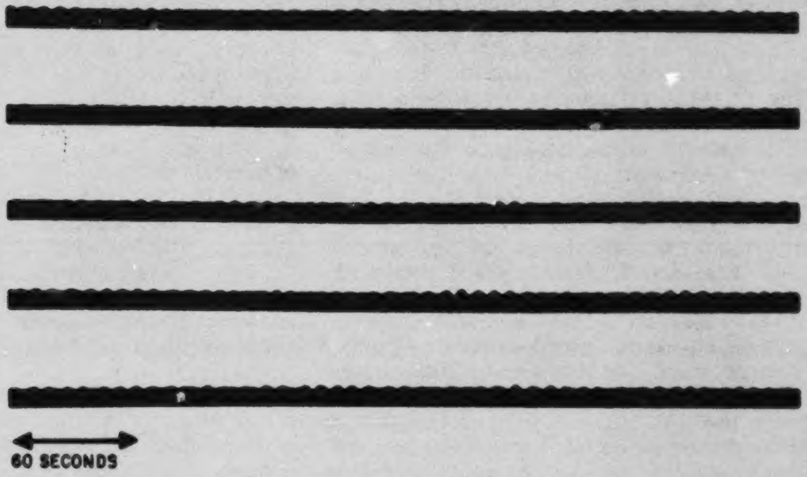
Swell consists of wind-generated waves which have left their generating area and are no longer subject to the original wind action. Consequently, the wave loses energy and changes its characteristics; height decreases and period increases. Characteristically, swell waves are low with rounded tops. Figures 10-7 and 10-8 graphically illustrate the differences in the configuration of sea and swell waves.

The swell waves following each other are nearly of the same height, and it is possible to follow a series of crests for long distances. This is in contrast to "sea waves," which are individually shaped with sharp angular tops; crests are not very long; and there are many small waves superimposed on the larger waves. Looking from one wave crest to the one immediately following, one can see that the heights are not regular. The individual crests are not lined up in the same direction. (See figs. 10-5 and 10-6.) There may be some places where for short distances the waves appear to be lined up and regular, but this is not a consistent occurrence. In most instances the sea waves will appear broken up and confused.



209.229

Figure 10-7.—Sea wave records.



209.230

Figure 10-8.—Swell wave records.

Surf Observations (SUROBS)

The breaking of waves, in either single or multiple lines, on sloping beaches or on rocky coastlines, is the phenomenon generally known as surf. The surf zone is the areal extent of the breaking waves, from the water up-rush on shore to the most seaward breaker. This zone will vary with the slope of the beach and the characteristics of the deep water waves.

The safety and success of amphibious landings is largely dependent upon known surf conditions. It is therefore essential that SUROBS be accurate and timely. The number of observations required will vary with the scope of the exercise.

Normally, the Aerographer's Mate does not observe, record, or report surf. If these observations are required in special situations, a comprehensive coverage of surf observation techniques may be found in the Joint Surf Manual, COMPHIBPACINST 3840.3( ).

Bathythermograph Observations

We have confined our previous discussion to observation of the surface of the sea. This is only part of the larger picture involved in describing the characteristics of ocean structure. It is also important to be able to observe the structure of the subsurface, or underwater variables. These include, but are not limited to, temperature, density, and salinity.

The sensing equipment used to determine ocean temperature data was discussed in chapter 4 of this manual. These instruments are valuable aids for gathering information on the structure of the sea. The other parameters require more sophisticated equipment not normally utilized by the Aerographer's Mate. However, without an organized means of recording and transmitting this temperature information, it would be of limited value. The following paragraphs provide information on the bathythermograph (BT) log.

THE BT LOG.—To aid the observer in interpretation of the BT trace and to assure the standardization of recording and reporting bathythermograph observations, the Oceanographer of the Navy and the National Oceanic and Atmospheric Administration have prepared a bathythermograph log for use by fleet units.

The BT Log, OCEANAV 3167/1 (6-72) is one of the most completely self-contained observational forms in use. It provides all the information required by the National Oceanographic Data Center (NODC).

UPPER AIR OBSERVATIONS

There have been many advances in the technological fields of high-altitude aircraft, projectiles, missiles, and satellite development. As a result of these advances, the scientific study of the upper regions of the atmosphere is becoming increasingly more important. Since meteorologists now have access to larger quantities of data from the upper air, they are finding new and more accurate methods of forecasting the movement of storms.

A knowledge of the weather conditions existing in the free air above the earth's surface is extremely important in theoretical, statistical, and climatological studies of the atmosphere as well as their importance in the direct application in daily forecasting and for their immediate use by pilots. Coupled with the information concerning surface conditions, this knowledge affords the forecaster another dimension upon which to base his predictions.

A basic understanding of the theory and purpose of upper air observations enables an Aerographer's Mate to understand better the processes he performs in taking observations. From the data thus obtained, maps, charts, and graphs of the upper air conditions at various levels up to many thousands of feet are constructed.

The types of equipment used in obtaining upper air observations were previously discussed in chapter 9 of this manual. The following information will discuss the types of observations, their schedules, forms used, and various upper air codes in use today. It is not the intent of this section to describe the many procedures to be followed in taking upper air observations. These are covered in Federal Meteorological Handbooks 3, 4, 5, and 6, that are readily available at all upper air observing stations.

Types of Observations

Upper air observations are measurements of the atmospheric conditions above the earth's surface. Upper air data may be determined by one or more of the following methods:

1. Pilot balloon (PIBAL). A pilot balloon observation is a measurement of the direction and speed of the wind above the earth's surface obtained by visual means. The direction and speed are computed from successive positions of a free balloon which is assumed to have a fixed ascensional rate. The positions are determined from values of the balloon's elevation and azimuth angle read each minute from a theodolite. The ascensional rate tables for pilot balloons are based on the averages derived from a large number of flights triangulated by two theodolites. The balloon may not be at the exact height given by the table because of the effect of local turbulence on the balloon. This turbulence may cause the balloon to be higher or lower than the height given in the table, but this discrepancy in height is not

enough to cause the sounding to be considered erroneous. The path that a balloon takes in flight is governed by the direction and speed of the winds through which it ascends.

Routine land and shipboard station pibals are taken by tracking the flight of the balloon with a single theodolite. On board ship a theodolite designed to reduce the effects of the pitch and roll of the ship is used.

2. Radiosonde balloon (RABAL). A rabal observation is a measurement of the direction and speed of the winds above the earth's surface obtained by visually observing a radiosonde's ascent with a theodolite. This type of sounding is more exact than pibals because there is no assumption made of the ascension rate of the balloon. The direction and speed of the wind are computed from successive positions of the balloon as computed from the angular readings of elevation and azimuth and the calculated height of the balloon.

3. Radio or radar wind (RAWIN). A rawin observation is a measurement of the direction and speed of the wind above the earth's surface obtained by electronic means. The height assumption of the pibal is eliminated. When radio direction finding equipment is used, the wind is determined from the calculations which combine the angular elevation and azimuth of a radiosonde signal with the computed height of the radiosonde. When radar equipment is used, the successive positions of the balloon are fixed by determining the azimuth angle and a combination of slant range and elevation angle, the slant range and heights, or elevation angle and height. (See fig. 10-9.)

4. Radiosonde observations (RAOBS). Raobs are taken to determine the pressure, temperature, and relative humidity from the surface to the point where the balloon bursts. The radiosonde consists of meteorological sensors, combined with a radio transmitter, which are assembled in a lightweight box. It is carried aloft by a balloon filled with helium.

Measurements of pressure, temperature, and relative humidity of the air are secured from signals transmitted by the radiosonde to a ground receiver where they are automatically recorded. The extreme altitude to which the radiosonde ascends is determined by the bursting point of the balloon. After the balloon has burst, the radiosonde is prevented from damaging property and injuring persons on its descent by a small parachute.

5. Rawinsonde. Rawinsonde observations give a simultaneous measurement of the pressure, temperature, humidity, and wind direction and speed of the air above the earth's surface. Rawinsonde observations combine the elements of the radiosonde and rawin observations.

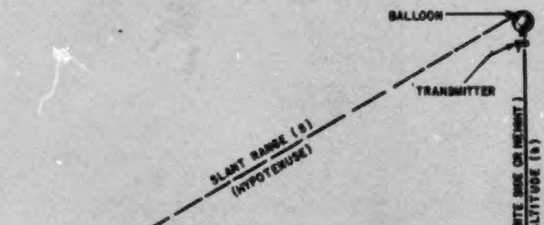
Observational Schedules

The standard times for upper wind observations are 0000, 0600, 1200, and 1800 GMT. However, delayed releases may be made within specified time limits.

Afloat, upper wind observations are desired at 0000 and 1200 GMT, daily, when underway greater than 180 nautical miles from a regularly reporting station. Ashore, at least two upper wind observations must be taken and recorded daily. Special winds aloft observations are taken and recorded afloat and ashore as required and directed by competent authority.

Forms and Charts

The following forms and charts are used to compute and record upper air data received from various methods. Procedures for requisitioning forms, along with a listing of them, are contained in the NAVAIR Allowance List, Section L, NAVAIR 00-35QL-22. Upper air charts used to compute radiosonde data are found in the DOD Catalog of Weather Plotting Charts, NW50-1G-518. It is essential that entries made on the forms be legible, and that the forms be



209.254

Figure 10-9.—Right triangle representing the parameters of an upper air sounding.

protected from soil and wrinkling. Most of these completed forms are eventually microfilmed.

OPNAV 3140-14 (MF5-20N).—Used to enter elevation, azimuth angles, altitudes, horizontal distances, slant ranges, and code data for transmission of winds—aloft observations. Additional columns are provided for shipboard computations.

OPNAV 3140-27 (NAVY WINDS ALOFT PLOTTING CHART).—A chart used by the Navy to plot computed wind direction and speed to corresponding altitudes for coding purposes.

OPNAV 3140-2 (RECCO FORM).—A form for entering coded data of reconnaissance flights from participating aircraft. Instructions for entries are contained on the form.

MF1-12 (PIREPS).—A form used to record pilot reports prior to dissemination.

MF31A, B, AND C (DOD-WPC 9-31A, B, C) ADIABATIC CHARTS.—A series of three charts for various heights, used to plot, compute, and encode radiosonde data.

Complete instructions for entries on all of the above forms, with the exception of OPNAV 3140-2, can be found in the appropriate Federal Meteorological Handbooks.

Upper Air Codes

As with all meteorological data, ease of dissemination of upper air observations is accomplished by coding the information in accordance with standards set forth in the Codes Manual and Federal Meteorological Handbooks No. 4 and 6.

The following is a brief description of the more frequently used codes. For a more complete coverage, along with some examples, refer to the applicable Federal Meteorological Handbook.

LAND UPPER WIND CODE (FM 32.( )).—The upper wind code for land stations, FM 32.( ), is designed to allow the reporting of wind conditions in the upper air. It is a relatively easy code to learn, but there are many technicalities and variations to the code, and these will have to be studied carefully.

The WMO symbolic form of the upper wind code, FM 32.( ), is divided into four parts—A, B, C, and D. Parts A and B are confined to data up to and including the 100-mb level, and parts C and D contain data above this level.

Section 1 of all four parts of the code contains the identification and position data. Section 2 of Part A contains data for the standard isobaric surfaces of 850, 700, 500, 400, 300, 250, 200, 150, and 100 mb; and Section 2 of Part C contains data for the standard isobaric surfaces of 70, 50, 30, 20, and 10 mb when pressure measurements and wind data are obtained simultaneously from the sounding. Section 3 of Parts A and C contain data for the level(s) of the maximum wind(s), with altitudes given in pressure in units of 1 mb or in units of geopotential decameters. Section 4 of Parts B and D contain data for fixed regional and/or significant levels, with altitudes given in units of 300 or 500 meters or significant levels with altitudes given in pressure to a whole millibar when pressure measurements and wind data are obtained simultaneously from the sounding.

SHIP UPPER WIND CODE (FM 33.( )).—The WMO symbolic code form of the shipboard upper wind code, FM 33.( ), is similar to the WMO land station upper wind code. The significant differences are the replacement of the station identifiers with the ship's position groups and the inclusion of the Marsden Square Number group, $MMMU_{La}U_{Lo}$ (used to verify the ship's position), following the position data in Section 1 of all parts.

LAND STATION RADIOSONDE CODE (FM 35.( )).—The complete radiosonde report is divided into four parts—A, B, C, and D—each of which is an individual message complete with position groups and separation signal. Parts A and C are specified for worldwide distribution and Parts B and D for areas of continental or WMO regional size. The United States (WMO Region IV) collects Parts A and B (data up to and including the 100-mb level) in a single message which is referred to as the first transmission and Parts C and D (data above 100 mb) as the second transmission.

SHIPBOARD RADIOSONDE CODE (FM 36.( )).—The symbolic form of the radiosonde code used by U.S. Navy ships is basically the same as the land station radiosonde code. The significant difference is the position symbolic groups used in Section 1 in all parts of the shipboard code.

Miscellaneous Coded Data

Data for the 850-, 700-, and 500-mb standard isobaric surfaces, low level mean winds, and the stability index are required by the National Meteorological Center and the Forecast Centers as soon as possible after the beginning of the ascent. Therefore, as soon as these data are obtained they are coded in a separate message for early distribution in accord with current communications instructions.

The data reported by means of the Early Transmission Message are additional to that reported for the 850-, 700-, and 500-mb standard surfaces included in the complete radiosonde report, and in no way affect the coding procedures specified for the preparation of that report. In other words, data for the 850-, 700-, and 500-mb surfaces are included in their usual places in the complete radiosonde report. Stability index is included only in the Early Transmission Message, and it is not included in the complete radiosonde report. Procedures for encoding can be found in FMH No. 4, Radiosonde Code.

All raob stations that file hourly aviation observations on longline teletypewriter circuits are required to append freezing level and icing data in the remarks portion of the first hourly observation following determination of the data. Procedures for coding and transmitting this data may be found in FMH No. 1, Surface Observations.

Pilot Reports

Pilot reports of meteorological phenomena encountered in flight are termed PIREPS. These reports are an extremely valuable source of information that often is not otherwise available. Weather observers should cooperate to the fullest extent possible with pilots and flight operation personnel to secure and disseminate this information. PIREPS are recorded on MF1-12.

CODING FOR DISSEMINATION.—The format for dissemination of PIREPS consists of a unique Text Element Identifier (TEI) as follows:

1. UA — Message type.
2. OV — Location of phenomena (location, time, flight level).
3. TP — Type of aircraft.
4. SK — Cloud information (bases, tops).
5. TA — Temperature (static air temperature).
6. WV — Wind information (airborne computer derived spot wind direction and speed).
7. TB — Turbulence (intensity, altitude or layer).
8. IC — Aircraft icing (intensity, altitude or layer).
9. WX - Weather (all types and leg wind components).

Each TEI, except for message type, will be preceded by a slash (/). If no data are received for a specific TEI, it will be omitted and all of the remaining data moved to the left.

RECCO Code

Weather reconnaissance, the collection of meteorological data by aircraft, is an important tool in providing forecasts for areas where data is sparse or nonexistent.

The code name RECCO is used as a prefix to the report, indicating that it is a report from a meteorological reconnaissance flight.

Present weather, cloud type and amounts, turbulence, and surface data are reported for a cylindrical portion of the atmosphere approximately 30 nautical miles in radius with the aircraft at the center at the time of the observation. The length of this cylinder extends from the earth's surface to the top of the atmosphere. Weather beyond the circumference of the observation cylinder is reported as off course weather.

The solidus (/) is used to report missing or unknown data unless otherwise specified for the individual elements.

The term "altitude" as used in this code, is defined as the vertical distance of a level point or an object considered as a point measured from mean sea level in metric units exclusively.

Plain language remarks may be added to the end of the report to supplement the coded data or supply additional information of importance not provided for in the code. If information on past weather is added, the most significant weather encountered since the last report, or in the last hour, whichever period of time is shorter, is described in the remark.

Sounding data obtained during vertical ascents or descents of the aircraft are reported using WMO code form FM 35.( ), (TEMP). Sounding data obtained from a dropsonde (Radiosonde AN/AMT-6( )) release are reported by means of FM 36.( ), (TEMP SHIP).

For complete information on the RECCO code, refer to OPNAV Form 3140-2( ) (Appendix VII).

NOTE: Changes to all column numbers and entries on NWSC Form 3140/8 were received too late for inclusion in this manual. Where errors in column numbers appear, refer to the U.S. Navy Supplement to FMH #1, Chapter 13, Marine Aviation Observations for the most recent amplifying instructions.

CHAPTER 11

WATCH ROUTINES (CONTINUED)

PLOTTING AND ANALYZING

Map plotting and analysis are two of the job functions that may be required during a watch period. This is especially true during a facsimile circuit outage, when no analyzed products are available. The training you received in map plotting and map sketching, while at the Aerographer's Mate "A1" School, gave you a basic understanding of the often used codes. In chapter 10 some of these codes which you have already learned were reviewed and new codes were introduced with which you may not be familiar.

The maps and charts that you will plot and sketch are of prime importance to all concerned because from these maps and charts you are able to locate pressure areas, fronts, precipitation areas, ridges, troughs, and numerous other meteorological phenomena of great importance. The maps and charts that you plot are determined by the geographical location of your weather station, its operational requirements, and its area of responsibility.

A thorough knowledge of the codes used and the employment of good map plotting practices should make you an excellent map plotter.

SURFACE CHARTS

The surface synoptic chart, when plotted and analyzed, is one of the "basic tools" of a forecaster. Accurate plotting of the chart is essential. Three things, in the order of their importance, for which the plotter of the chart must strive are ACCURACY, NEATNESS, and SPEED.

Outline charts for selected areas of the world are provided for the plotting of synoptic weather reports (reports of observations made at weather stations over a large area at a given time). These charts are termed Weather Plotting Charts. The DOD number, title, map projection, scale, and illustration of the various charts are found in the latest edition of the Catalog of Weather Plotting Charts (NW 50-1G-518).

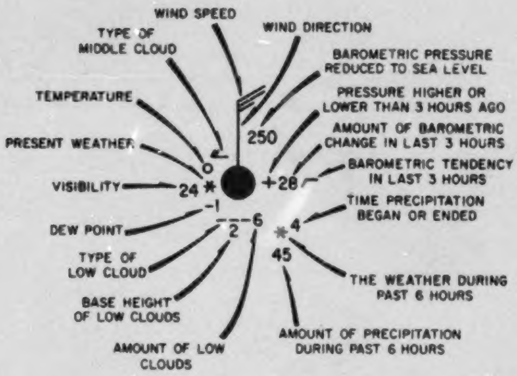
A small station circle is printed on the charts at the geographical location of the major reporting stations. On maps, where the density of reporting stations is a maximum for the scale of the map, station circles are placed in the general location of the station. Stations are identified on the printed map by their assigned station numbers adjacent to the station circle.

Not all reporting stations are shown on the charts. When it is desirable to enter a report from one of these stations, the person plotting the map draws a circle in the location of the station. To facilitate locating stations, all ships and stations should have a master plotting chart which shows all station locations by correctly positioned station circles with both the station index number and name of the station.

This chart can be kept up to date by referring to the Air Weather Service Manual 105-2 Vol-II and the latest changes to it. For every area of International Index Number Stations, there is a master plotting chart which may be obtained by request to the nearest Stock Point.

The term "weather map" is applied to a weather plotting chart after the synoptic reports have been entered around the station circle as shown in figure 11-1. The term is also applied to the chart after the analysis has been made.

There is neither a specified allowance nor an initial distribution of meteorological plotting charts. The responsibility for requisitioning the


WIND SPEED
TYPE OF MIDDLE CLOUD
WIND DIRECTION
BAROMETRIC PRESSURE REDUCED TO SEA LEVEL
TEMPERATURE
PRESSURE HIGHER OR LOWER THAN 3 HOURS AGO
AMOUNT OF BAROMETRIC CHANGE IN LAST 3 HOURS
PRESENT WEATHER
BAROMETRIC TENDENCY IN LAST 3 HOURS
VISIBILITY
TIME PRECIPITATION BEGAN OR ENDED
DEW POINT
TYPE OF LOW CLOUD
THE WEATHER DURING PAST 6 HOURS
BASE HEIGHT OF LOW CLOUDS
AMOUNT OF PRECIPITATION DURING PAST 6 HOURS
AMOUNT OF LOW CLOUDS
250
+28
24
-1
6
2
4
45

209.298

Figure 11-1.—Synoptic station model—land station.

charts rests with each weather unit. The charts are ordered from the applicable Defense Mapping Agency Aerospace Center (DMAAC) outlet in accordance with instructions on the procure page of the latest edition of the Catalog of Weather Plotting Charts (NW 50-1G-518).

Surface charts are normally plotted every 6 hours from the synoptic observations of 0000, 0600, 1200, and 1800 GMT. (For communication purposes the letter "Z" has been assigned as a short designator for GMT.)

The name of the station, date, time, plotter's initials, decoder's initials, and name or initials of the analysts should be entered on EVERY weather map. ALWAYS REMEMBER IN METEOROLOGY THAT ANY MATERIAL WITHOUT A TIME AND DATE IS PRACTICALLY USELESS.

The plotting of simultaneous (synoptic) weather reports enables the forecaster to obtain a more comprehensive "picture" of the existing weather conditions for a given period of time over a large area. When the weather map has been completely plotted, it is analyzed for forecasting purposes. This aids the forecaster in his primary duty, which is the preparation and issuing of weather advices and forecasts.

Plotted Surface Data

The basic data plotted on surface synoptic charts are the land and ship station surface synoptic reports. Our concern here is with the information plotted on the surface chart and its use.

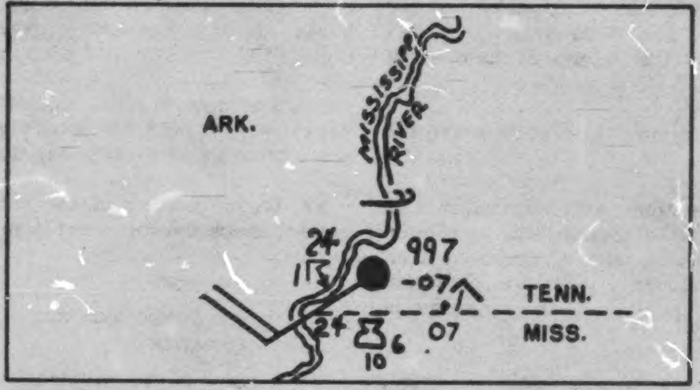
Land station or ship station synoptic observations are encoded in accordance with instructions contained in FMH No. 2. Synoptic Code (NA 50-1D-2) or International Meteorological Codes (Year) Worldwide Synoptic Broadcasts NA50-1P-11. Normally, only the first five groups and the 7-indicator group of the land station synoptic report are entered on the surface chart as illustrated in figure 11-2 (A).

For ship reports, the use of groups is a little more complicated. A station circle is drawn at the place indicated by the two position groups. The meteorological information is plotted next. This information is found in the remaining groups of the code. Ordinarily, the plot includes the wind group, the weather and visibility group, the pressure group, the cloud group, the pressure tendency group, the sea temperature/dewpoint group, and the wave group, as shown in figure 11-2 (B). Ship plots are complicated by the fact that three types of reports are usually available from them—the full form, the short form, and the abbreviated form. The short form and the abbreviated form do not contain all the meteorological information that the full form contains. A specific weather office may have need for all the information transmitted in both the land station and ship reports. Perhaps the need may apply only to certain elements like the rain group, or to ice information; possibly the needs are only temporary. In such cases the additional information is plotted and analyzed.

LAND STATION CODE PLOTTING.—There are many variations to the synoptic code. The difference in most cases is small, but very important. Be sure to check the WMO Region in which you are stationed or operating for the differences in the code that is employed in your area. The synoptic code format was given in the previous chapter. The U.S. land station plotting model for the code is shown in figure 11-1.

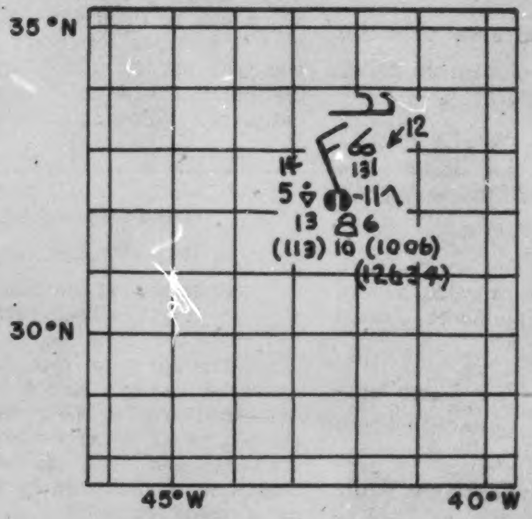
In general, the data contained in a synoptic report is plotted around the station circle in a counter-clockwise manner, beginning with pressure. This is the easiest method; however, if you can plot in an easier order, use it. The important thing to remember is to plot in the same order all the time to avoid missing elements.

(A)


ARK.
MISSISSIPPI
RIVER
24
15
997
-07
TENN.
24
07
MISS.
6
10

72334	82219	16956	99724	59402	24807	69890	70710
(II)iii	Nddff	VVwwW	PPPTT	$N_hC_lhC_MC_H$	$T_dT_d$app	$6P_oP_oP_oP_o$	$7RRR_ts$

(B)


35°N
30°N
45°W
40°W
12
66
131
14
5
-11
13
86
(113)
10
(1006)
(12634)

99322	70421	07004	73515	97802	13114	52472
$99L_aL_aL_a$	$Q_cL_oL_oL_oL_o$	YYGG1	Nddff	VVwwW	PPPTT	$N_hC_LhC_MC_H$

54811	00413	11132	31006	12634
$D_sV_s$app	$0T_sT_sT_dT_d$	$1T_wT_wT_wt_T$	$3P_wP_wH_wH_w$	[illegible] $d_wP_wH_wH_w$

209.299

Figure 11-2.—(A) Basic land synoptic plot; (B) basic ship synoptic plot.

The following procedures are employed for plotting most codes, and have generally been standardized so that the minimum amount of confusion will result:

1. Indicator figures for code groups are not plotted.

2. Most wind directions are reported in tens of degrees. The wind direction, dd, is plotted as the wind direction, in tens of degrees, from which the wind is blowing. When the direction is missing, the ddff portion of the message is not normally plotted.

3. All wind speeds are plotted in knots. They are plotted as shown in the winds aloft section of chapter 17.

   a. A half barb (1/8 inch) represents 5 knots.

   b. A full barb (1/4 inch) represents 10 knots.

   c. Pennants (1/4 inch) represent 50 knots.

   d. A calm wind consists of a circle drawn around the station circle.

Any combination of a, b, and c may be employed to represent the correct speed. You should plot "X" at the end of the wind shaft when the speed is missing.

4. Wind direction and speed are usually plotted first so that true direction may be shown, and interference with other elements plotted is kept to a minimum.

5. Minus signs are plotted with subzero temperatures.

6. If any mandatory plotted element is garbled or partly or wholly missing, plot the letter "M" in its place.

7. All elements that are plotted are oriented to the adjacent latitude and longitude lines.

8. All legends should be filled out as indicated in the printed portion of the map containing the legend block. If a legend block is missing, information normally entered in the printed legend is entered in the lower left-hand corner of the map. The entries may be rubber stamped or printed block entries. Do not forget your name and rate in the legend.

9. Data plotted around a station circle should cover an area not greater than a dime if possible.

10. The code figures that are coded for temperature (TT) and dewpoint (T_dT_d) are reported and plotted as whole degrees Celsius.

11. When plotting of the map has been completed, check the following items:

   a. Neatness

   b. Wind direction and speed plotted correctly.

   c. Size of station plots.

   d. Completeness (all available data plotted).

   e. Entry of late and off-time reports.

   f. In case of ships, proper location.

12. There are inks of several different colors which can be used when plotting a map to indicate the types of data plotted. Although no standard set of colors exists in the Navy, and the colors used are normally determined locally, the following colors are recommended:

   a. Black or blue-black—On-time data or blocks of off-time data (so indicated in the map legend).

   b. Red—Gradient winds and off-time data.

   c. Green—Data that are entered after the map has been plotted.

13. Be sure to plot the past positions of pressure centers and fronts on the map. The past positions of the pressure centers are indicated by an X circumscribed by a circle with the date and time placed immediately above. The date is indicated by two numbers followed by a colon or solidus (/) indicating the day of the month. The second two numbers indicate the time of data to the nearest whole hour GMT preceding the time of the appropriate map. Thus, 1200Z on the 20th day of the month is entered as 20:12Z (or 20/12Z).

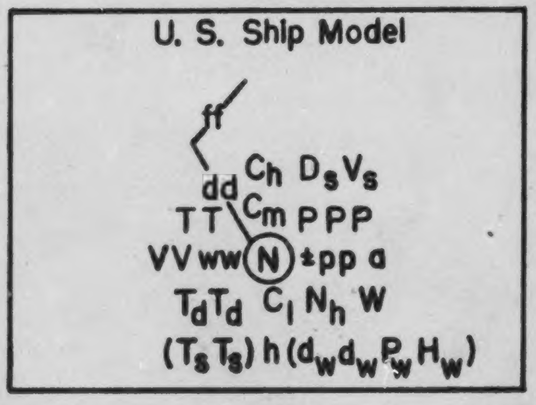
SHIPBOARD CODE PLOTTING.—At sea there is a lack of the close network of land reports, and a single ship report may be the only one in a vast area. A single ship report, too, may be the only one giving an indication of a developing tropical storm which may be heading for a task force or a heavily populated area. It is especially important that the location of the ship be plotted accurately as well as complete plotting of the data around the station circle.

Surface synoptic reports from ships are identical with land synoptic reports with the exception of the position groups, the direction and velocity of the ship group, the group in which difference between sea water and air temperature is encoded, and the ice group. The ice group is omitted if there is no ice.

Figure 11-3 shows the grouping entries around the U.S. ship plotting model.

The first elements to check are the day of the month (YY) and the time (GG), to be sure that the report is consistent with the date-time-group of the chart being plotted.

Next determine the quadrant of the globe to determine if it will fit on the chart you are plotting. If it fits, then locate the latitude and longitude ($L_aL_aL_a$, $L_oL_oL_oL_o$). When this position has been located, draw a 3/16-inch circle at this point. The next four groups are plotted in the same manner as the land synoptic code with the exception of the wind group, which must be decoded and plotted according to the wind indicator group (I_W). If this group is a "0" or "1", the wind is in meters and should be doubled before plotting. If it is a "3" or "4", wind is in knots and plotted as reported.
Refer to figure 11-2 (B) for an illustration of the plotting of a ship's report.



209.286
Figure 11-3.—U.S. ship plotting model.

ASYNOPTIC (OFF-TIME) PLOTTING.—Since a "synoptic chart" is one showing meteorological conditions observed at various places over a region at or very near the same given Greenwich time, it readily follows that "asynoptic data" are those data not normally appearing on a synoptic chart by virtue of being observed at a different time. In other words, asynoptic data may be termed "off-time" data. Although there is question as to how much difference may exist between observation time and synoptic chart time, and here again local rules have to apply, asynoptic data provide valuable supplements to synoptic data in areas where synoptic reporting stations are sparse or in case of communications failure. Frequently, asynoptic reports indicate significant weather developments not apparent at map time.

The criteria for asynoptic surface data is surface observations more than 1 hour from the synoptic chart time.

A color code, such as the one given in a previous section of this chapter, should be adopted for plotting such data. These plotted reports must be distinguished from the regular synoptic data because enough changes generally occur during the time intervals to yield an inaccurate or inconsistent analysis if the off-time data were treated as synoptic.

AIRWAYS CODE PLOTTING.—When bad or hazardous weather is approaching the station, it often becomes necessary to supplement the synoptic map with 3-hourly airways maps. These may be either a regular synoptic type chart or a sectional chart. At times it may even be necessary to enter hourly airways maps. These charts give a detailed analysis over a limited area of the relation of pressure systems, fronts, temperature, and humidity to operationally significant weather elements. These maps also enable the forecaster to keep a "weather eye" on the situation and to note any sudden or unusual changes which are occurring.

The Airways Code is probably the most familiar of all weather codes. It is used not only when weather reports are made from MF1-10, but can be used to plot airways charts and to fill in areas of sparse or little data on synoptic charts.

Since the airways maps, when plotted, are subject to careful scrutiny, it is imperative that they be entered both rapidly and accurately. The size, type, and scale of the map, and the amount of data to be plotted are governed by local requirements.

The arrangement of data around the station circle is essentially the same as for the land synoptic code plotting model. Figure 11-4 (A) and (B) shows a typical station model used for plotting, and a plotted model of the 3-hourly airways code data.

METAR CODE PLOTTING.—The METAR code is used in foreign countries in lieu of aviation hourly weather reports. With the numerous ships and overseas duty stations to which Aerographer's Mates are assigned, it is necessary that a working knowledge of this code be maintained.

The station model format is depicted in figure 11-5 (A) along with an actual plot of a METAR report shown in figure 11-5 (B).

Surface Chart Analysis

When all available synoptic weather reports have been entered on the weather map, it is ready for analyzing. A preliminary step in

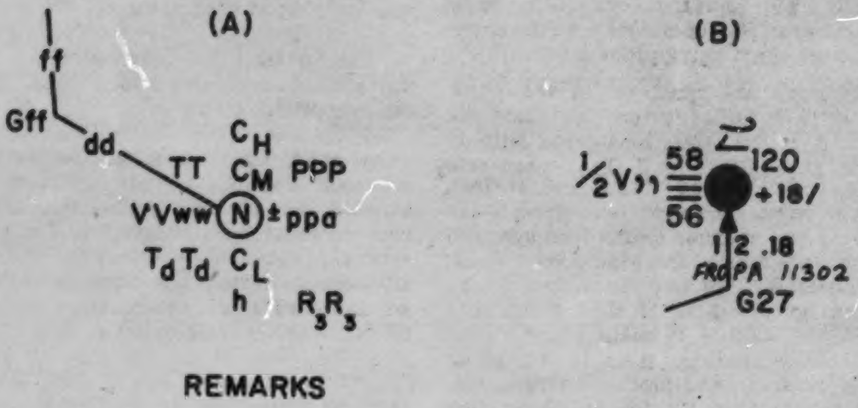

(A)
ff
Gff
dd
TT
C H
C M
PPP
VVww
N
± ppa
Td Td
C L
h
R3R3
REMARKS
(B)
½V
58
56
120
+18/
1 2 .18
FROPA 11302
G27

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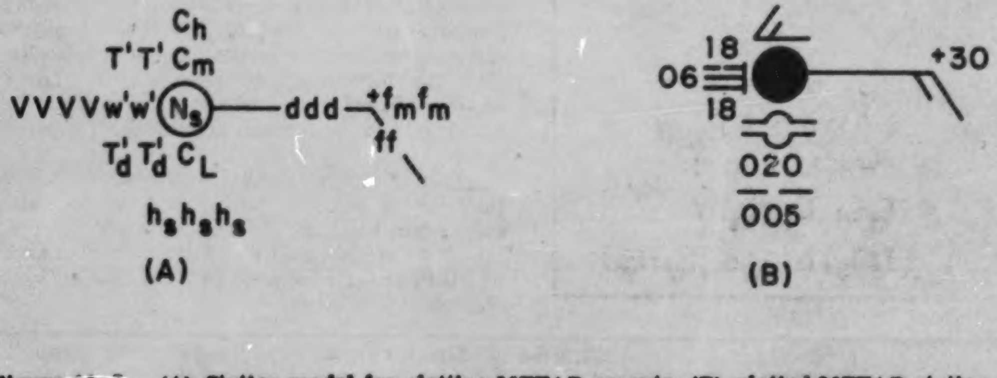
Figure 11-4.—(A) Station model for plotting airways reports; (B) plotted airways station model.


Ch
T'T' Cm
VVVVw'w'
Ns
ddd
+fmfm
ff
T'd T'd CL
hshshs
(A)
18
06
18
+30
020
005
(B)

209.406

Figure 11-5.—(A) Station model for plotting METAR reports; (B) plotted METAR station model.

analyzing the surface weather chart is to study the previous charts and draw past fronts and pressure systems (with a yellow pencil) on the chart being analyzed. The past history of the weather is very important and very significant. In most weather offices it is the practice to enter the past history on a chart BEFORE it is even plotted. Prior to tracing past history, any corrections to previous analyses that may be necessary due to late or additional reports should be made. In any event, the study of the past history of the weather is the FIRST STEP in map analysis, whether the chart is the surface chart, a constant pressure chart, or a supplementary chart.

The second step leading to the complete analysis consists of visually scanning the chart and noting the plotted information, areas of high and low pressure and the general windflow. Also check for obviously erroneous reports. When a report is discovered to be doubtful, first check for accuracy before discarding it. The wind group may have been garbled, but the remaining entries may be correct. A misplot of ship position is the most frequently made plotting error. A check against the original report should relocate the report and make it perfectly useable.

Isobaric Analysis

The third step consists of lightly sketching lines in pencil to connect points of equal pressure. These lines, called isobars, outline areas of high and low pressures.

The drawing of an isobar is merely the drawing of a line which follows the general windflow and connects points having equal numerical pressure values. The numerical values referred to when drawing isobars are the pressure values plotted near each station circle.

Isobars are drawn for 4-mb intervals from 25° latitude poleward and for 2-mb intervals from the Equator to 25° latitude using 1,000 millibars as the base value. To determine the exact values for which isobars are drawn between the Equator and 25° N and S, use 1,000 millibars as a base value and proceed toward both increasing and decreasing values by increments of 2 millibars.

To determine the exact values for which isobars are drawn in the area between the poles and 25° N and S, use 1,000 millibars as a base value and proceed toward both increasing and decreasing values by increments of 4 millibars.

Isobars should be drawn so that they agree not only with the pressure, but also with the wind. The distance between isobars should agree with the reported wind speeds. The stronger the wind, the closer the isobars are to one another. It must also be kept in mind that winds blow across isobars at a slight angle, inward toward a center of low pressure and outward from a center of high pressure. If the terrain is smooth, this angle is small; however, the rougher the terrain becomes, the greater is the angle. Over ocean areas, winds blow across the isobars at an angle of 10° to 20°; over very rough land, the angle may be as much as 40°.

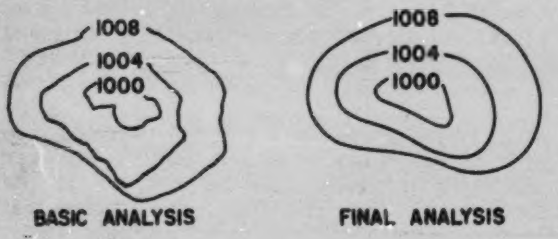
In representing large-scale movement of the air, simple isobars are more probable than complicated isobars. (See fig. 11-6.) The illustration at the left side of figure 11-6 shows how the beginner draws the isobars to fit the barometer readings precisely. The illustration on the right side of figure 11-6 shows the isobars correctly drawn to take the shape of smooth lines. An irregular appearance is frequently due to minor errors in observations. Hence, irregularities that do not show any systematic arrangement are likely to be the reflection of errors. If a reported pressure seems incorrect, compare it with the previous report from the same station to determine whether the pressure change is probable.

Isobars must always appear as simple curved lines or as closed lines. Isobars may begin and end in the following manner:

1. Originate on one edge of the chart, trace a path connecting points of equal pressure values, and terminate on any edge.
2. Begin anywhere on the chart, trace a path connecting points of equal pressure values, and join ends to form a closed curve.

ISOBARS REPRESENTING DIFFERENT PRESSURE VALUES NEVER TOUCH OR CROSS. Touching or crossing signifies two different pressures at the same time and place, which is impossible.

In drawing isobars over large areas, start in a region where they are easy to draw. Drawing isobars over land areas where observations are numerous is less difficult than over ocean areas where reports are limited. The best method is to draw isobars over land regions



209.300

Figure 11-6.—Smoothing of isobars.

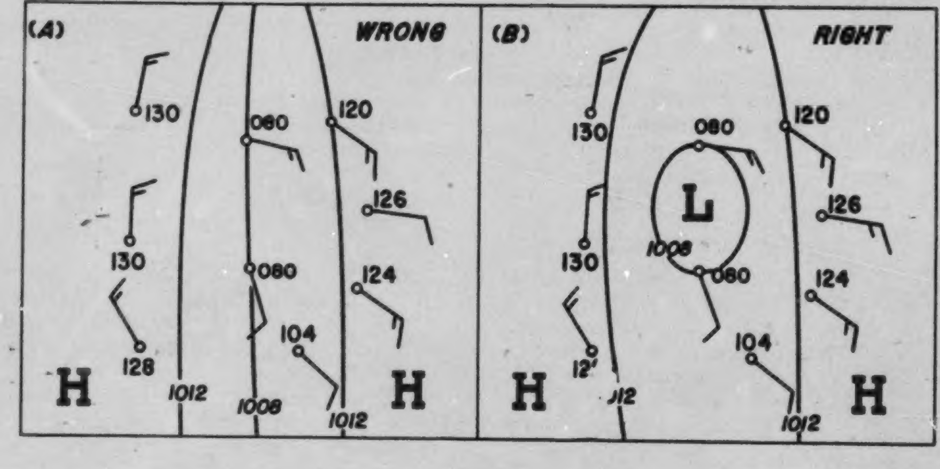
first; then extend the isobars over adjacent oceans. Other conditions being equal, it is easier to draw isobars in areas of strong wind than where the winds are weak. Isobars should be drawn so they agree logically with the preceding map. The previous map is the key to the present chart. For example, suppose that the preceding map shows a young, deepening cyclone. The present map should show that the low has moved a reasonable distance and deepened. The deepening is indicated by new and closer isobars around the center.

In drawing an isobar, keep in mind that the higher pressures are on one side of the isobar and the lower pressures are on the other side. (See fig. 11-7.) If pressures are higher (or lower) on both sides of an isobar than the value of the isobar itself, a mistake has been made.

The 2-station method of analysis is a very good method by which to actually begin and complete the basic analysis.

The first step in the 2-station method of analysis is to select the area of the chart over a land surface where numerous reports are available. Locate the area of highest and lowest plotted pressure values. Select one region and locate in this region the station having the highest or lowest plotted pressure value. Note this pressure value. Go in any direction from this station to a station immediately adjacent. Note the pressure at this station. Determine what standard isobaric value, if any, fits between these two stations in a logical numerical order. If a standard isobar can be drawn between these two stations, draw a short pencil line between these two stations and more or less parallel with the wind shafts at the two stations. If a standard isobar does not fit between the two stations, continue in the same direction to the next adjacent station and repeat the entire process outlined above.

Note the plotted pressure values at several stations immediately downwind from the point of origin. If it is found that the numerical value of the isobar being drawn fits, in a logical numerical order, between only two of these stations, project the short line being drawn to



209.302

Figure 11-7.—A small pressure center between isobars.

this new point. Repeat the search, always downwind. Project the isobar to the new point. This procedure is repeated until the isobar being drawn runs off one edge of the chart, returns to the point of origin (the ends join to form a closed curve), or enters an area where there are no reports and there is no justification for continuing.

Remembering that all points along an isobar represent the same numerical pressure value, move from the finished isobar, at any point, outward to an adjacent station. Determine if another isobar, of greater or lesser value, may be placed between this station and the isobar just completed. If so, proceed in the same manner outlined above. If not, continue in the same direction to the next adjacent station. Eventually, an area between two stations is encountered where the next standard isobar may be drawn; then proceed in the manner outlined above.

This process is repeated until an isobar has been drawn for all standard values insofar as the plotted information permits.

The next step in analysis is locating and sketching frontal positions. Careful isobaric analysis aids significantly in locating the more obvious fronts.

Frontal Analysis

The location of fronts is determined by past history, air mass analysis, satellite data, and reports on the present charts. Since fronts and their accompanying weather move across various areas of the earth in established directions with somewhat definite speeds, it is possible to follow their movement on previous charts as an aid to locating them at any particular time.

In locating fronts, properties of the air masses have to be studied and the fronts have to be located so that they separate unlike air masses.

COLD FRONTS.—Cold fronts are normally located in well-defined pressure troughs whenever there is a marked temperature contrast between two air masses. In most cases, a careful analysis of the isobars indicates the correct position of the pressure trough that contains the front. This method of isobaric analysis is frequently the only possible means of locating fronts over ocean areas or regions of scanty surface reports. Other indications of the presence of cold fronts can be classified as prefrontal, frontal, or postfrontal indications and are as follows:

1. Pressure tendencies. In advance of cold fronts, the tendency characteristic is usually indicated by a steady or an unsteady fall. The isallobars of falling pressure in advance of the front usually form an elongated pattern approximately parallel to the front. After the passage of the front, the tendency generally shows a steady rise, and stations behind the front show a tendency characteristic of ∨, ✓, or /. The first two, showing a fall and then a rise in pressure, indicate that the front passed the station during the 3-hour period prior to map time.

2. Wind. With the approach of the front, the wind is normally from the south or southwest in the Northern Hemisphere, veering to parallel the front. At the passage, the wind generally shifts abruptly to the northwest. Very gusty winds frequently occur at the frontal passage and usually after passage.

3. Cloud forms. In advance of cold fronts, the cloud types are typical of the warm air. Towering cumulus, cumulonimbus, stratocumulus, and nimbostratus are associated with the passage. After passage, these cloud forms may prevail for several hundred miles with the slow-moving cold front. Very rapid clearing conditions are associated with the fast-moving cold front after passage. Well back in the cold air in both types of cold fronts, the only clouds normally found are fair weather cumulus.

4. Precipitation. Showers and sometimes thunderstorms occur with the cold-front passage. Continuous precipitation is observed for some hours after the passage of a slow-moving cold front. Showers and thunderstorm activity of short duration will occur with the passage of a fast-moving cold front, followed by very rapid clearing conditions.

5. Temperatures. Temperature is relatively high prior to passage. After passage, the temperature decreases very rapidly with slow-moving fronts. Such a rapid temperature change does not accompany the passage of fast-moving cold fronts; the real temperature change is usually observed some distance (as far as 50 to 100 miles) behind the front.

6. Dewpoint. The dewpoint temperature generally aids in locating fronts. This is especially true in mountainous regions. A drop in the dewpoint is observed with the passage of either type of cold front.

7. Visibility and ceiling. With the approach and passage of a slow-moving cold front, the visibility and ceilings decrease and remain low after the passage until well within the cold air. Fast-moving cold fronts are preceded by regions of poor visibility and low ceilings due to shower activity. After passage of fast-moving cold fronts, the ceiling rapidly becomes unlimited and the visibility unrestricted.

WARM FRONTS.—Active warm fronts are generally located in pressure troughs on the surface charts. The troughs are not as pronounced as those observed with cold fronts; therefore, other meteorological elements are utilized as follows in locating warm fronts accurately:

1. Pressure tendencies. Pressure usually falls for an appreciable length of time prior to the frontal passage. Normally, it is steady after passage. The tendencies in advance of the front are therefore ╲ (steady or unsteady fall). A warm frontal passage is usually indicated by a ╲_ tendency.

2. Wind. The wind in advance of warm front in the Northern Hemisphere is usually from the southeast, shifting to southwest after passage. The wind speed normally increases as the front approaches. The wind shift accompanying a warm front is seldom as abrupt as with a cold front.

3. Cloud forms. Warm fronts are nearly always well defined by typical stratified clouds. They are generally cirrus, cirrostratus, altostratus, nimbostratus, and stratus, with the cirrus appearing as much as 1,000 miles before the actual surface passage. The cloud types that form after passage of the warm front are typical of the warm air mass.

4. Precipitation. The precipitation area of warm fronts extends about 300 miles in advance of the surface front. Precipitation occurs mainly in the form of continuous or intermittent rain, snow, or drizzle. However, when the warm air is convectively unstable, showers and thunderstorms may occur in addition to the steady precipitation.

5. Temperature and dewpoint changes. Abrupt temperature changes, like those characteristic of cold fronts, do not accompany the warm frontal passage. Instead, the temperature change is gradual. It starts increasing slowly with the approach of the front and increases slightly more rapidly with the passage. The dewpoint is normally observed to rise as the front approaches, and a further increase follows the frontal passage when the air in the warm sector is of maritime origin.

6. Visibility and ceiling. The visibility and ceilings are normally good until the precipitation begins. Then they decrease rapidly. Dense fog frequently occurs in advance of a warm front. An improvement is experienced after passage.

OCCLUDED FRONTS.—Because the occlusion is a combination of a cold front and a warm front, the resulting weather is a combination of conditions which exist with both fronts. Ahead of a cold type occlusion, as the warm air is lifted, all the clouds associated with a warm front are found producing typical prefrontal precipitation extensively for a distance of 250 to 300 miles. Typical cold frontal weather is found throughout the narrow belt in the vicinity of the surface front. However, the thunderstorms are less intense than those of a typical cold front, since the source of warm air has been cut off from the surface and the energy received comes only from the warm air trapped aloft. Instability showers often follow the cold front when the cold air is unstable. The most violent weather occurs on the upper front for a distance of 50 to 100 miles north of the northern tip of the warm sector. After the occlusion has passed, the weather usually clears rapidly. Figures 14-13 and 14-14 of this manual show vertical cross sections of cold type and warm type occlusions. Figure 14-15 shows the occlusions and their associated upper fronts.

The weather associated with the warm type occlusion (fig. 14-13) is very similar to that of the cold type occlusion. With the warm type occlusion, the high-level thunderstorms associated with the upper cold front develop quite some distance ahead of the surface front (up to 200 miles), and the weather band, in general, is wider (up to 400 miles). The air behind the cold front, flowing up the warm frontal surface, causes cumuliform type clouds to form. In this area, precipitation and severe icing may be found. The most violent weather occurs on the upper front, 50 to 100 miles north of the northern tip of the warm sector.

SECONDARY COLD FRONTS.—In the last stages of an extratropical cyclone, there is a tendency for troughs of a low pressure to form to the rear of the primary trough. A secondary front may occur in this trough. Secondary cold fronts usually occur during outbreaks of very cold air behind the initial outbreak. Secondary cold fronts may follow in intervals of several hundred miles to the rear of the rapidly moving front. Usually, in the case of the formation of a secondary cold front, the primary front tends to dissipate, and the secondary front then becomes the primary front. Secondary fronts do not usually occur during the summer months because it is rare for enough temperature discontinuity to exist.

QUASI-STATIONARY FRONTS.—When the past history is accurate, quasi-stationary fronts are easily located. Merely look for them in the same general vicinity as on the previous maps. A previously quasi-stationary front which has moved a considerable distance should not be classified as a quasi-stationary front. Instead, it should be called either a cold front or a warm front.

The weather along quasi-stationary fronts is usually a mixture of cold frontal and warm frontal weather. Often there is no weather along the quasi-stationary front. There is usually little difference in temperature across a quasi-stationary front, and the same holds true for the dewpoint. Pressure changes are ordinarily very small across quasi-stationary fronts and the characteristic of the barograph trace is indefinite. Usually the wind shift across a quasi-stationary front is small. Isobars do not often form a well-defined trough; nevertheless, they do kink at the front toward higher pressure. The best indicator of the quasi-stationary front is the cloud deck. A good past history with a band of clouds and little difference otherwise is usually a good indication that the quasi-stationary front is still in existence.

From the above it can readily be seen that the studying of many station reports, past and current, is important in locating and determining the movement of fronts. Examine all reports in detail to determine the types of fronts present and their characteristics.

Once isobars have been drawn for all standard values possible in conformance with the plotted data and the fronts have been located, the weather map is ready for final analysis.

The final analysis consists primarily of smoothing out any irregularities in the isobars which were drawn during the basic analysis.

Erase the innermost isobar in a pressure center. Using a freehand stroke, redraw the isobar so that it has a smooth shape or appearance. After the isobar has been smoothed, label it with the appropriate millibar value which it represents. (See fig. 11-6.) Erase the next isobar away from the center, smooth it, and label it with the appropriate millibar value which it represents. Continue the smoothing process until all isobars which were sketched during the basic analysis have been erased, redrawn smoothly, and labeled.

The isobars near fronts should be drawn so as to bring out the frontal discontinuity of the horizontal pressure gradient. Correctly drawn isobars are kinked without exaggeration at a front, with the kink always pointing toward higher pressure as in figure 11-8.

After all isobars have been smoothly redrawn and labeled with their representative pressure value, draw the fronts, using the colors and symbols as shown in figure 11-9. Then label all high-pressure centers with a blue block

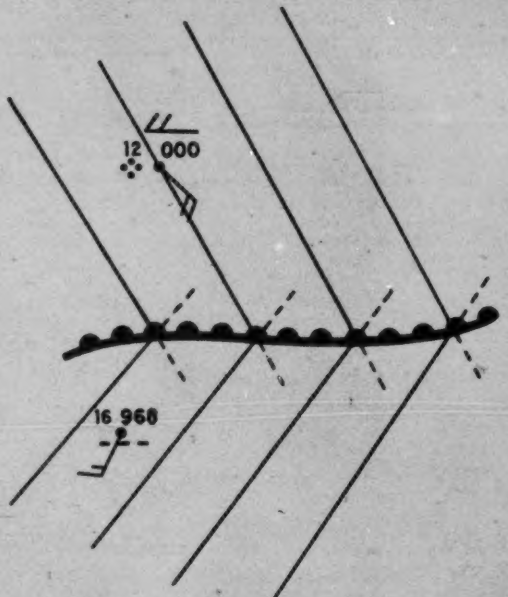


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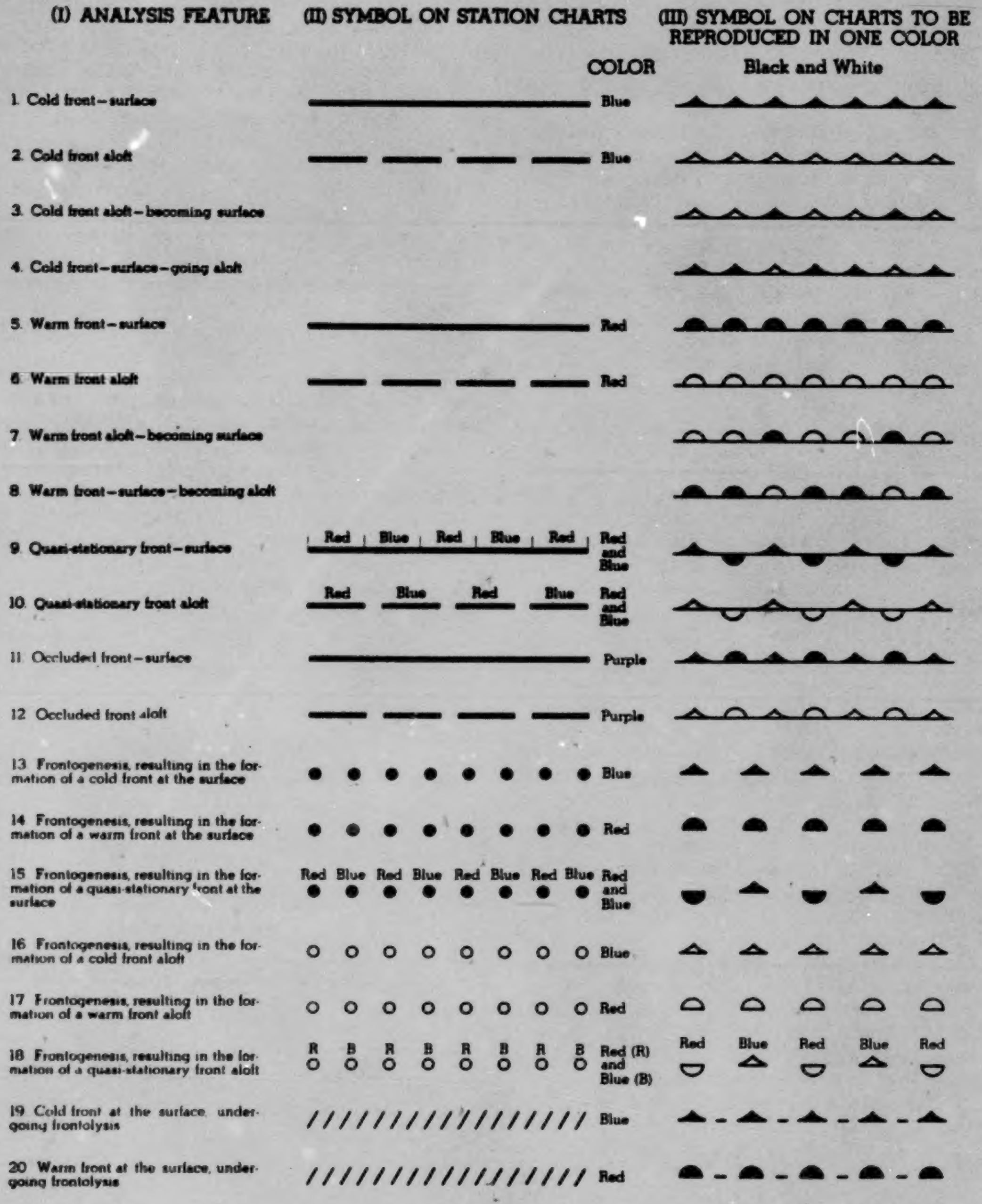
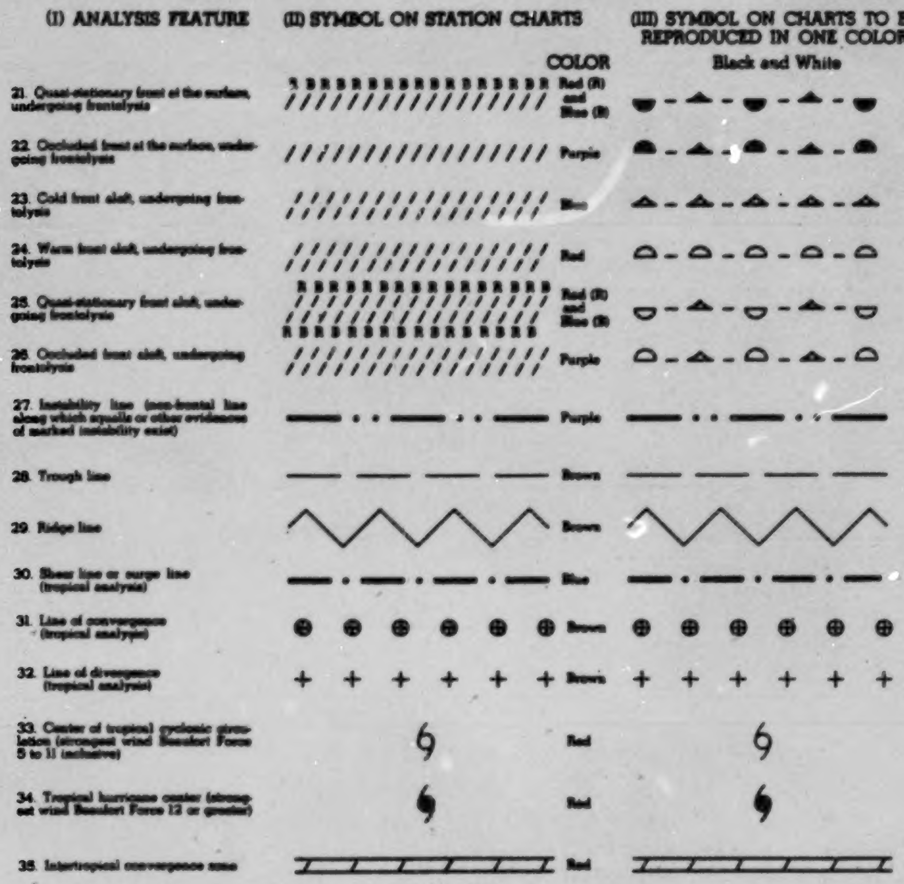
Figure 11-8.—Isobars at a front.


(I) ANALYSIS FEATURE
(II) SYMBOL ON STATION CHARTS
(III) SYMBOL ON CHARTS TO BE REPRODUCED IN ONE COLOR
COLOR
Black and White
1. Cold front—surface
Blue
2. Cold front aloft
Blue
3. Cold front aloft—becoming surface
4. Cold front—surface—going aloft
5. Warm front—surface
Red
6. Warm front aloft
Red
7. Warm front aloft—becoming surface
8. Warm front—surface—becoming aloft
9. Quasi-stationary front—surface
Red | Blue | Red | Blue | Red
Red and Blue
10. Quasi-stationary front aloft
Red Blue Red Blue
Red and Blue
11. Occluded front—surface
Purple
12. Occluded front aloft
Purple
13. Frontogenesis, resulting in the formation of a cold front at the surface
Blue
14. Frontogenesis, resulting in the formation of a warm front at the surface
Red
15. Frontogenesis, resulting in the formation of a quasi-stationary front at the surface
Red Blue Red Blue Red Blue Red Blue
Red and Blue
16. Frontogenesis, resulting in the formation of a cold front aloft
Blue
17. Frontogenesis, resulting in the formation of a warm front aloft
Red
18. Frontogenesis, resulting in the formation of a quasi-stationary front aloft
R B R B R B R B
Red (R) and Blue (B)
Red Blue Red Blue Red
19. Cold front at the surface, undergoing frontolysis
Blue
20. Warm front at the surface, undergoing frontolysis
Red

209.305

Figure 11-9.—Weather analysis symbols.


(I) ANALYSIS FEATURE
(II) SYMBOL ON STATION CHARTS
COLOR
(III) SYMBOL ON CHARTS TO BE REPRODUCED IN ONE COLOR
Black and White
21. Quasi-stationary front at the surface, undergoing frontolysis
Red (R) and Blue (B)
22. Occluded front at the surface, undergoing frontolysis
Purple
23. Cold front aloft, undergoing frontolysis
Blue
24. Warm front aloft, undergoing frontolysis
Red
25. Quasi-stationary front aloft, undergoing frontolysis
Red (R) and Blue (B)
26. Occluded front aloft, undergoing frontolysis
Purple
27. Instability line (non-frontal line along which squalls or other evidences of marked instability exist)
Purple
28. Trough line
Brown
29. Ridge line
Brown
30. Shear line or surge line (tropical analysis)
Blue
31. Line of convergence (tropical analysis)
Brown
32. Line of divergence (tropical analysis)
Brown
33. Center of tropical cyclonic circulation (strongest wind Beaufort Force 8 to 11 inclusive)
Red
34. Tropical hurricane center (strongest wind Beaufort Force 12 or greater)
Red
35. Intertropical convergence zone
Red

NOTES

1. In symbols 1-12 inclusive, Column III, barbs may be separated more than shown, but a continuous line will always be drawn through the bases of the barbs.
2. In symbols 13-18 inclusive, Column III, the barbs will always be separated and will always be drawn without a connecting line.
3. In symbols 19-26 inclusive, Column III, the barbs may be spaced a greater distance than shown here, but the length of the dash between barbs should equal the space between the dash and each adjacent barb.
4. In symbol 35, Columns II and III, the spacing between the continuous lines will normally be about ½ inch, but may be greater when the intertropical convergence zone is broad.

209.305.1

Figure 11-9.—Weather analysis symbols—Continued.

letter H, and label all low-pressure centers with a red block letter L.

After the final analysis is complete, the following become apparent:

1. Isobars representing different pressure values never touch or cross.

2. Isobars never split.

3. The spacing between isobars is directly related to the wind speed. The closer the isobars are to one another, the stronger the wind; the wider the space between isobars, the weaker the wind.

AIR MASS	SYMBOLS	COLOR OF ENTRY
Arctic, continental	cA	Blue
Arctic, maritime	mA	Blue
Polar, continental	cP	Blue
Polar, maritime	mP	Blue
Tropical, continental	cT	Red
Tropical, maritime	mT	Red
Equatorial	E	Red
Superior	S	Red

The air masses are also defined thermally as follows:

SYMBOL	ENTRY	THERMODYNAMIC STATE
k	Blue	Air mass is colder than the surface over which it is passing.
w	Red	Air mass is warmer than the surface over which it is passing.

209.305.2

Figure 11-9.—Weather analysis symbols—Continued.

4. Isobars must agree not only with the pressure, but also with the general windflow. Winds blow in a clockwise direction about a high-pressure area and counterclockwise about a low-pressure area in the Northern Hemisphere. Because of the effect of surface friction, winds blow across isobars at a slight angle from high to low pressure.

5. Isobars "kink" at fronts.

Isobaric Patterns

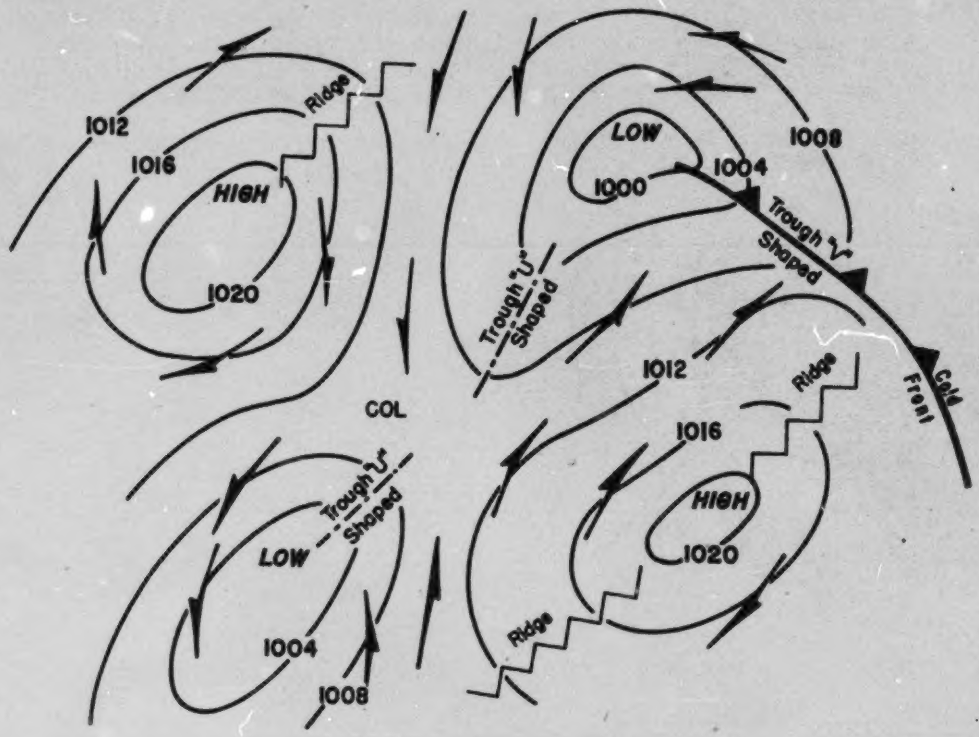
Frequently, reference is made to various isobaric patterns. Some of the basic patterns are described below and shown in figure 11-10.

RIDGE (OR WEDGE).—A ridge is an elongated area of relatively high pressure that extends from the center of an anticyclone or high. The wind circulation is essentially anticyclonic in the Northern Hemisphere. Ridges of high pressure are usually areas of fine fair weather. They are found between two distinct low-pressure areas.

COL (OR SADDLE).—The col is a region between two highs and two lows. The col is one of the most treacherous types of barometric distribution. Sometimes the col marks a locality of fine weather, while at other times severe thunderstorms are experienced.

TROUGH.—A trough is an elongated area of relatively low pressure and usually extends from a low-pressure area. The isobars of a trough may be either U-shaped or V-shaped. U-shaped troughs contain no fronts, while V-shaped troughs are associated with fronts. Unsettled or bad weather and a possibility of a formation of a secondary front may be expected with U-shaped troughs. In V-shaped troughs the weather elements vary sharply.

In drawing isobars in the vicinity of mountainous regions, special care must be taken.



209.303

Figure 11-10.—Basic isobaric patterns.

Stations in these regions reduce their pressure to mean sea level; in so doing, discrepancies may occur. It is advisable to have a topographic chart of the terrain in order to determine whether apparent packing of the isobars on a previous map is due to the mountain barrier effect or a steep pressure gradient actually being present.

Isallobaric Analysis

An isallobar is a line of equal pressure change. In other words, isallobars are lines of equal pressure tendency and are usually drawn for an interval of 1-mb change. For example, all stations having a pressure tendency plotted as minus 10 would be connected with a line representing a 1-mb change.

Isallobars drawn for plus values are normally drawn on the chart in dashed blue lines, and isallobars for minus values are drawn in dashed red lines. (See fig. 11-11.)

Isallobars are reliably indicative of the direction in which pressure systems have been moving, and consequently are useful in forecasting the movements.

Air-Mass Analysis

The air masses have been studied as the frontal analysis was made, now they must be classified and labeled. The current properties and the past history of the air mass are the guidelines to classification of the air masses. (See ch. 14.)

It is customary to indicate the air-mass classification by placing the appropriate symbol on the weather map in the location of the air mass. The symbols used are given in figure 11-9.

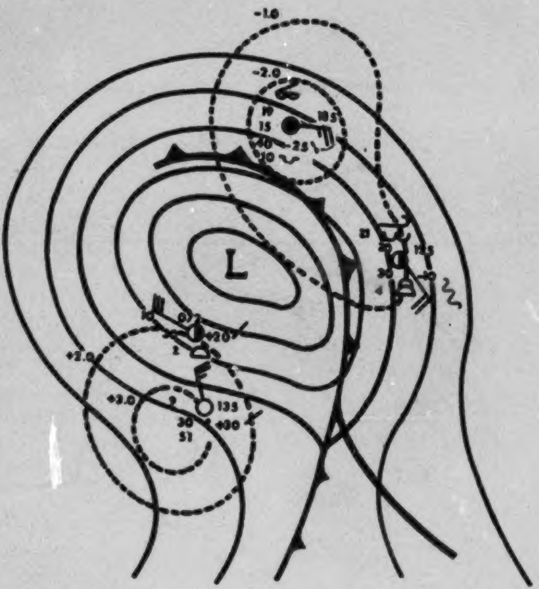


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Figure 11-11.—Isallobars.

Weather Analysis

A thorough study of the weather on the surface chart has been made as the map has been analyzed. It is now time to indicate the intensity and characteristics of the precipitation and of some of the other weather phenomena. This is done by shading and/or use of symbols as shown in table 11-1.

Movement Analysis

The next step is to determine the present rate of motion of the fronts and pressure systems. The past rate of motion is already indicated from the past history of the pressure systems and the fronts. After the past and present motions of fronts and pressure systems are determined, their future movement is considered.

It is standard procedure in weather offices to place the expected movement of pressure systems and fronts on the current weather chart. (See fig. 11-12.)

Two of the primary methods for determining movement of these systems are by their movement on previous charts and by the pressure tendencies on the current chart. For example, the low in figure 11-12 the position for each 12-hour period is noted and placed on the chart. If the 1200Z chart for the ninth day of the month is being analyzed and a low-pressure system is located at position 3, and on the previous 12-hour charts it was located at positions 1 and 2, it could be assumed that 12 hours hence the system would be at position 4.

High-pressure areas move toward areas of positive pressure tendencies; low-pressure areas move toward areas of negative pressure tendencies.

Summary

The following summary is the recommended procedure for analyzing a surface weather map:

1. Draw the fronts and pressure systems of the preceding map on the current chart with a yellow pencil. Study the previous charts for historical sequence.

2. Sketch the isobars lightly, preferably one pressure system at a time. Isobars should be adjusted (fig. 11-8) in order to locate the fronts as accurately as possible.

3. Locate and sketch the fronts.

4. Redraw each isobar smoothly and neatly. Label all isobars.

5. Draw the fronts in appropriate color.

6. Label the high-pressure areas with an H, using a blue pencil. Label the low-pressure areas with an L in red pencil.

7. Draw the isallobars in appropriate color and label them.

8. Label air masses.

9. Color the precipitation areas.

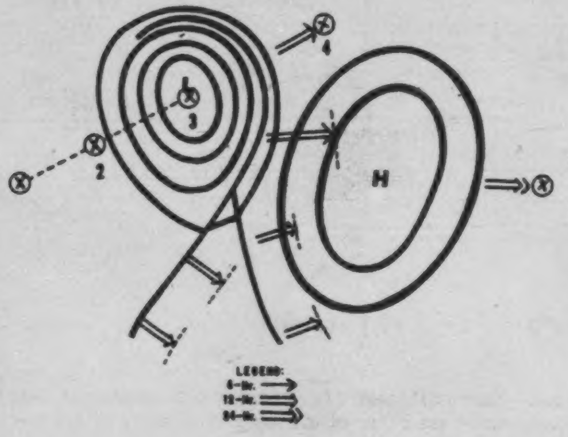
10. Determine the past, present, and future rate of motion of fronts and pressure systems.

International Analysis Code
(FM 45.( ) and 46.( ))

Underway at sea, you may find that because of other duties time cannot be spared

Table 11-1.—Standard precipitation coloring

Precipitation areas	Coloring
Areas of continuous precipitation.	Light green shading.
Areas of intermittent precipitation.	Light green hatching.
Areas of showers.	Green shower symbols.
Areas of drizzle.	Green drizzle symbols.
Areas of past thunderstorms.	Red thunderstorm symbols.
Areas of present thunderstorms.	Green thunderstorm symbols.
Areas of fog.	Light yellow shading.



209.308
Figure 11-12.—Forecast movement of fronts and pressure systems.

to plot all ship and coast station reports available for drawing a weather map. On such occasions, an analyzed weather map and/or prognosis showing the centers of pressure systems, the fronts, and isobars drawn from data given in the coded analysis message may meet the local requirements. Also, in cases of communications failure which precludes the receipt of facsimile transmissions, this coded analysis or prognosis may be the only source upon which the weather officer has to base his forecasts.

This code reduces to a numerical code form a weather map prepared at forecasting centers of meteorological services. Data included in these messages give the types, characteristics, central pressures, locations, and movements of pressure systems and position points for use in drawing the fronts and isobars. Types of fronts (whether warm, cold, occluded, or stationary) and the values for the isobars are also indicated in the messages. The message may be either a current map analysis with indications as to movement or development, or a prognostic map analysis.

The international code, FM 46( ), was designed primarily for marine use. It is an abridged form of FM 45( ), and the symbolic letters and figures have the same meaning in both codes.

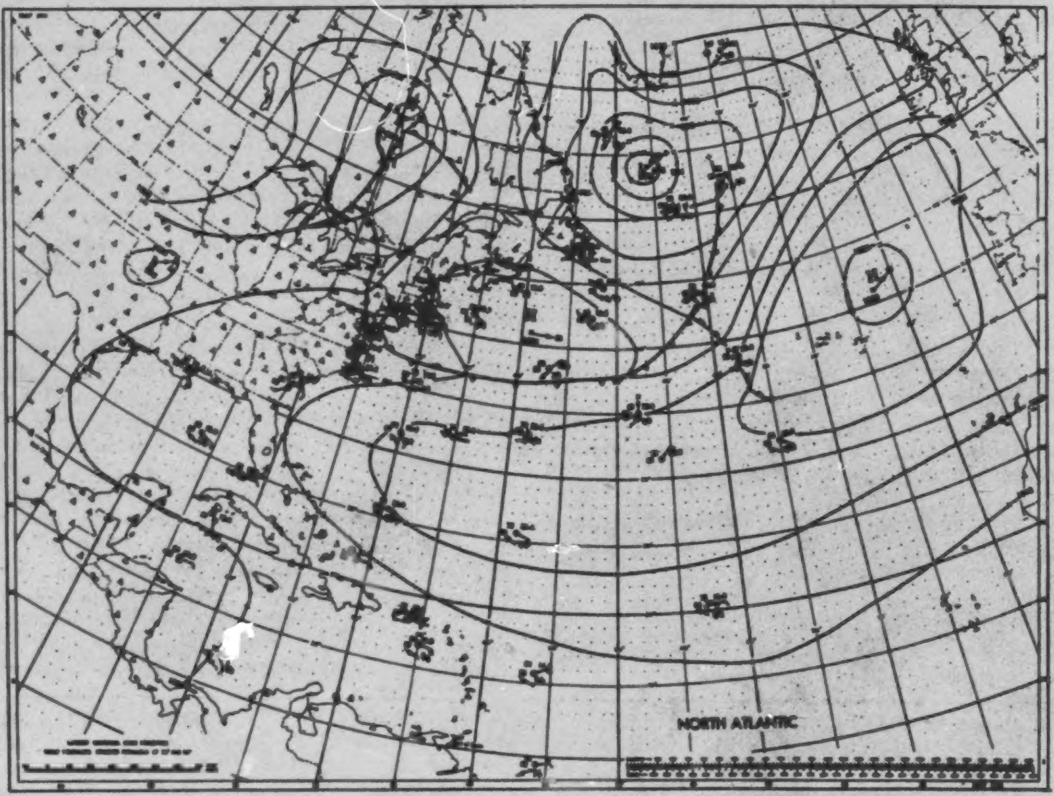
The symbolic form and an explanation of the letter specifications of these codes, refer to the International Meteorological Codes (YEAR) and Worldwide Synoptic Broadcasts NA50-1P-11. For an example of a plotted map of the International Analysis Code, see figure 11-13.

UPPER AIR CHARTS

Map analysis includes not only surface weather charts but also upper air charts. The upper air charts used in conjunction with the surface charts are essential for accurate forecasting. With the aid of upper air charts, the forecaster gets a 3-dimensional view of the synoptic situation.

The flow pattern of the air in the free atmosphere above the layer of frictional influence next to the earth is indicative of the type of weather that will occur at the surface of the earth. The direction in which pressure systems, fronts, tropical storms, and the like move depends upon the windflow above the frictional layer of the atmosphere. It is necessary to determine this factor from upper air charts.

The basic upper air charts in use today are termed CONSTANT PRESSURE CHARTS,



North Atlantic weather map drawn from reports included in a shipping bulletin broadcast. Crosses at the centers of lows and highs, and along the isobars and fronts shown on the map, are for the purpose of explaining the plotting of weather maps from coded analyses messages.

209.291

Figure 11-13.—Map showing plotted IAC-FLEET analysis.

since they depict conditions existing along a constant pressure surface. They are a valuable aid in forecasting any weather conditions for any locality.

A constant pressure chart is a chart showing meteorological data at a particular standard level. The meteorological data for these charts are obtained from radiosonde and rawinsonde observations. The standard pressure levels mentioned are those levels for which mandatory data are transmitted in the radiosonde code. These include the 1,000-, 850-, 700-, 500-, 400-, 300-, 250-, 200-, 150-, 100-, 70-, 50-, 30-, 20-, 10-, 7-, 5-, 3-, 2-, and 1-mb levels. The taking, coding, evaluating, and dissemination of radiosonde observations are discussed in other chapters of this training manual.

From time to time and from place to place there are different pressures at a particular level in the atmosphere. The constant pressure charts are designed to show these differences of pressure in space and time.

Although constant pressure charts may be prepared for any or all of the mandatory levels, the most common charts in use are the 850-, 700-, 500-, 300-, 200-, and 100-mb charts.

The approximate heights of the constant pressure surfaces are as follows:

Millibar chart	Meters	Feet
1,000	110	370
850	1,460	4,780
700	3,010	9,880
500	5,570	18,280
400	7,180	23,560
300	9,160	30,050
200	11,790	38,660
150	13,620	44,680
100	16,210	53,170

As previously mentioned, constant pressure charts are primarily used as an aid in weather forecasting. They are used in conjunction with surface synoptic charts to accomplish the following:

1. Determine movements of weather systems.
2. Determine cyclonic and anticyclonic windflow.
3. Help define air masses.
4. Locate moist and dry areas.
5. Aid in forecasting the formation, intensity, and dissipation of pressure systems.
6. Determine the actual slopes of fronts.
7. Determine the vertical extent of pressure systems.
8. Forecast the jetstream.

Plotted Data

The meteorological data entered are the height of the standard pressure level above sea level, the temperature and dewpoint depression at the standard pressure level, and the wind speed and direction at the standard pressure level.

The meteorological plotting chart used for plotting constant pressure data is the same as that used for surface synoptic data. It is properly labeled for whatever pressure value the chart is being constructed (850 mb, 700 mb, etc.); it is also marked with date and time.

The information plotted on a constant pressure chart is obtained from the radiosonde and rawinsonde reports received by teletype, radio, or computer. The coded formats of these messages were described and discussed in an earlier section of this chapter. These charts are usually plotted and analyzed every 12 hours; they represent the data obtained from the 0000 and 1200 GMT radiosonde and rawinsonde releases. Figure 11-14 is a representative entry of data on a constant pressure chart (700 mb).

Some stations require that the dewpoint depression be plotted. In this case, the depression is subtracted from the temperature to obtain the dewpoint.

Winds aloft reports may be plotted on separate charts or may be used to fill in stations on the constant pressure charts which do not take or transmit radiosonde data. Extreme care should be taken when plotting the wind direction and speeds on these charts, as many areas of the world are using streamline analyses almost exclusively on upper air charts. A misplotted direction or an incorrect speed could cause an entirely erroneous analysis in a crucial area.

When wind speed and direction are critical in the analysis of an upper air chart, the following procedure is recommended:

1. Plot all wind directions with a protractor, using the latitude and longitude lines for orientation. Draw the wind shaft to the station circle. (See fig. 11-14.)

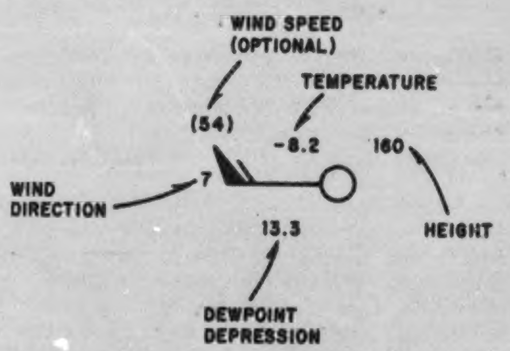


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Figure 11-14.—Constant pressure chart plotted report.

2. Indicate the speed of the wind by the appropriate number of feathers, pennants, or combinations of both.

3. Place the tens number of the wind direction on the end of the wind barb shaft.

4. Optional entries normally governed by local procedure are:

a. To place the actual wind speed in parentheses at the tip of the wind feather or pennant indicating the speed;

b. To draw the wind shaft through the station circle with an arrowhead on the end pointed in the direction toward which the wind is blowing.

If the wind is calm, draw a circle around the station circle. If the wind is missing, do not make an entry for the wind. If the wind direction is encoded and the speed is missing, enter an X at the end of the wind shaft where the wind feather is normally located.

The height is entered as encoded to the northeast of the station circle, the temperature to the northwest of the station circle in degrees and tenths, and the dewpoint depression (or dewpoint) to the southwest of the station circle in degrees and tenths.

If the height, temperature, or dewpoint depression is missing, enter a dash in the appropriate space for each of these elements.

RECCO CODE PLOTTING.—The RECCO code, explained in the previous chapter, enables the airborne weather observer to encode elements peculiar to aircraft flight in addition to the required standard meteorological values.

The report designator always precedes the report and means that the following code data have been obtained from aerial meteorological reconnaissance aircraft in flight. A report that is one of a series from a particular aircraft is generally identified by the name of the flight and number of the report. (EXAMPLE: VULTURE ONE, VULTURE TWO, etc.) An aircraft on a tropical cyclone reconnaisance further identifies the report by adding the name of the storm. (EXAMPLES, VULTURE SUSIE ONE, VULTURE SUSIE TWO, etc.)

In plotting the RECCO code, the first element to check is the day of the week (Y) and the time (GGgg) to make sure that the report is consistent with the time of the map being plotted. After locating the position of the report on the map from the latitude and longitude groups in the proper octant of the globe, draw a small rectangular box on the map at the proper location.

Figure 11-15 (A) and (B) shows the RECCO code plotting model for constant pressure charts and actual plotted report.

Upper Air Chart Analysis

With the failure of facsimile circuits or in the case of unique situations, the Aerographer's Mate may be called upon to analyze constant pressure charts. In order for them to be able to carry out these duties, it is necessary that they know the vertical structure of highs and lows, frontal positions aloft, and the basic techniques of constant pressure chart analysis.

Upper Air Features

The surface weather chart depicts pressure systems only in a horizontal extent. The vertical extent and orientation of the pressure systems depend on the temperature of the atmosphere.

The rate of change of pressure with height depends primarily on the temperature. The pressure changes most rapidly in a vertical plane when the temperature is low, least rapidly when it is high. Remember that pressure is a function of the weight of the atmosphere, and the

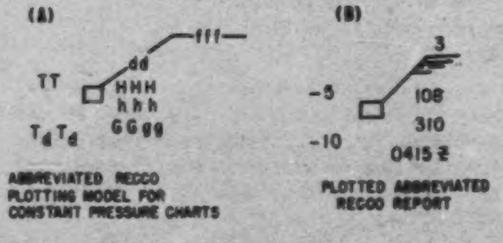
(A)
fff
dd
TT
HHH
hhh
GGgg
TdTd
ABBREVIATED RECCO PLOTTING MODEL FOR CONSTANT PRESSURE CHARTS
(B)
3
-5
108
310
-10
0415 Z
PLOTTED ABBREVIATED RECCO REPORT

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Figure 11-15.—(A) RECCO code plotting model (constant pressure chart); (B) plotted RECCO report.

weight of the atmosphere depends upon the density. Cold air is denser than warm air. Therefore, cold air must exert more pressure at a given altitude. Assume that two columns of air are exerting the same pressure at the surface; the column containing the warmer air has to extend to a greater altitude to exert a pressure at the surface equal to that exerted by a column of colder and denser air. Since the height of the colder column is less, it follows that the pressure must decrease more rapidly with altitude in the colder air, and the vertical spacing of isobars is closer together. For this reason, a pressure system on the surface does not necessarily exist aloft. On the other hand, under the proper temperature conditions, a pressure system may intensify with height.

High- and low-pressure systems are classified as either cold core or warm core systems.

COLD CORE HIGH.—A cold core high is one in which the temperatures on a horizontal level decrease toward the center.

Because the temperature in the center of a cold core high is less than toward the outside of the system, it follows that the vertical spacing of isobars in the center of this system is closer together than on the outside. Although the pressure at the center of these systems on the surface may be high, the pressure decreases rapidly with height. (See fig. 11-16.) (For the purpose of illustration, figures 11-16 through 11-19 are exaggerated from the way that they appear in actual atmospheric conditions.)

Examples of cold core highs are the North American High and the Siberian High.

WARM CORE HIGH.—A warm core high is one in which the temperatures on a horizontal level increase toward the center.

Because the temperatures in the center of a warm core high are higher than on the outside of the system it follows that the vertical spacing of isobars in the center is farther apart than toward the outside of the high. For this reason, a warm core high increases in intensity with altitude. (See fig. 11-17.)

Examples of warm core highs are the Azores or Bermuda High and the Pacific High.

COLD CORE LOW.—A cold core low is one in which the temperatures decrease on a horizontal level toward the center.

Because the temperatures are colder in the center of a cold core low, it follows that the isobaric surfaces in a vertical plane are closer together in the center. For this reason, cold core lows increase in intensity with height. (See fig. 11-18.)

Examples of cold core lows are the Aleutian Low and the Icelandic Low.

WARM CORE LOW.—A warm core low is one in which the temperatures increase toward the center in a horizontal plane.

Because the temperatures are greatest in the center of a warm core low, it follows that

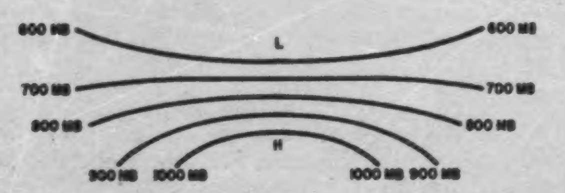

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Figure 11-16.—Cold core high.

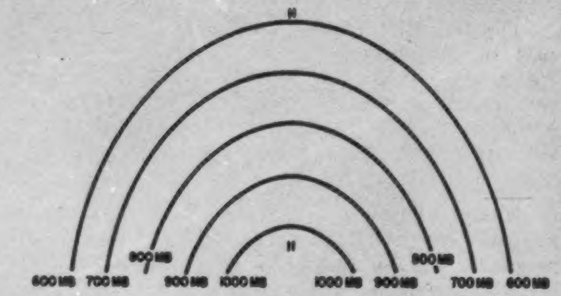

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Figure 11-17.—Warm core high.

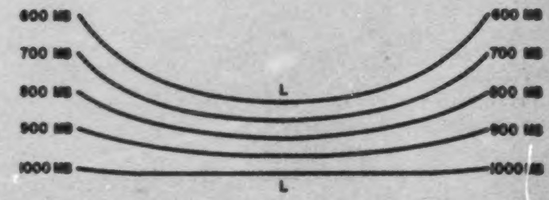

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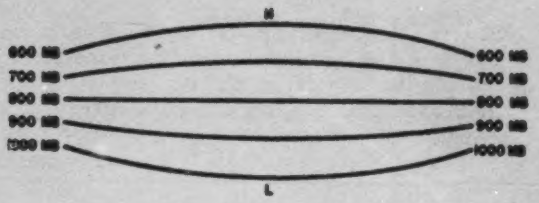
Figure 11-18.—Cold core low.

the isobaric surfaces in the center are farther apart in the vertical than toward the outside where the temperatures are lower. For this reason, warm core lows disappear rapidly with altitude. (See fig. 11-19.)

Examples of warm core lows are the Equatorial Low and the thermal lows that form over land areas during the summer.

VERTICAL AXES.—The vertical axes of pressure systems are seldom perpendicular. Lows tend to slope toward colder air aloft and highs toward warmer air. Thus, the position of pressure centers in the upper air will not necessarily coincide with their position on the surface. (See fig. 11-20.)



209.312
Figure 11-19.—Warm core low.

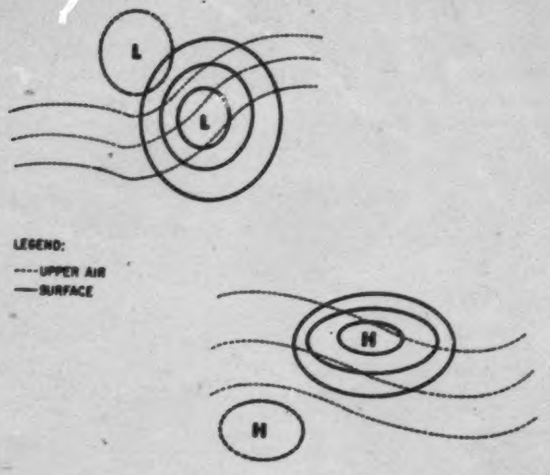


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Figure 11-20.—Comparison of pressure systems.

Analysis Elements

CONTOURS.—Contours or isoheights are lines of equal height drawn on a constant pressure chart. These contours show the height of the constant pressure surface in question; they are drawn for 30-meter, 60-meter, or 120-meter intervals as appropriate. For constant pressure charts up to the 300-mb level, contours are drawn for 60-meter intervals. For levels at and above the 300-mb level, 120-meter intervals are used. In cases in which the gradient is weak or in order to delineate pressure centers, intermediate intervals (30-meter or 60-meter) may be used. Contours are the upper air equivalent of isobars. They look about the same as isobars, but are usually much smoother. They are drawn for meter intervals rather than pressure intervals, as are the isobars. Contours are labeled in accordance with the specifications listed in table 11-2.

The contours on the constant pressure charts show smooth, sweeping orientations of troughs and ridges instead of the confused pressure distribution often found on surface charts. Normally, they parallel the wind direction and are spaced inversely proportional to the wind speed. Closed high- and low-pressure systems appear less frequently on constant pressure charts than on surface charts.

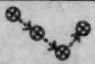
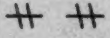
High and low areas can be located by the reported height values. Lows have a lower height value than the surrounding reported heights, and highs have higher reported heights than the surrounding reported heights. High and low systems on constant pressure charts are labeled in the same manner as on surface charts. An H in blue denotes a high, and a red L denotes a low.

FRONTS.—Fronts can normally be located on the constant pressure charts up to and including the 700-mb level by the wind direction, temperature, and moisture distribution. Fronts are either drawn on the charts in the same manner as surface charts or are shown simply by a trough line.

ISOTHERMS.—Isotherms are lines of equal temperature, which are drawn for every 5° of temperature, beginning with any value divisible by 5. The Navy standard color for isotherms is red.

ISODROSOTHERMS.—Lines of equal dewpoint are isodrosotherms. They are drawn in

Table 11-2.—Standard upper air chart markings

Element	Marking	Interval	Label	
			Where	Units
Contours (isoheights).	Solid black pencil line. (Dashed black pencil line for intermediate interval.)	60-meter interval up to 300-mb level. 120-meter interval at and above 300 mb.	*	Thousands, hundreds, and tens.
Isotherms	Solid red lines	5° C	*	Degree Celsius.
Isodrosotherms.	Very light solid green lines.	10° C	*	Degree Celsius.
Fronts, highs, lows, troughs, and ridges.	Standard symbols as shown in figure 21-8.		Same general procedures as surface charts.	
Forecast movements.	Red: Low and trough. Blue: High and ridge. 6 hr ⟶ 12 hr ⟶ 24 hr ↠ (Black)		At present location, pointing in direction of forecast movement.	
Past movement (centers).	 (In ink.)		At past position.	
Isotachs	Short dashed green lines.	20 knots	At edges of chart—around closed axes.	Knots.
Jetstream	Thick solid purple line with arrowhead.	Minimum wind speed of 50 knots	Along axis of maximum wind speed.	
Tropopause	 (Black pencil.)		Where observed.	
Thickness lines.	Dashed, black lines	60-meter		Thousands, hundreds, and tens.
Advection arrows.	Cold—Blue arrow. Warm—Red arrow.	At every upper and lower contour intersection.		
Rise and fall lines.	Rise—Solid blue pencil lines. Fall—Solid red pencil lines. (Connecting points of equal rise or fall.) Zero—Purple.	60-meter	*	Meters
Rise and fall centers.	Same as movement (centers).			

*At edges of chart and around closed systems, usually at the top and/or bottom of the closed isopleths.

NOTE: Miscellaneous isopleths, such as potential temperature lines or tropopause isopleths, may be drawn in the manner of contours when they are the primary features and contours are not used in that particular analysis.

green for every 10° of dewpoint, beginning with any value divisible by 10.

OTHER FEATURES.—There are numerous other features analyzed on constant pressure charts, but third and second class Aerographer's Mates are not required to know the details and the techniques of these features. The features are the tropopause, the jetstream, isotachs (lines of equal wind speed), thickness lines, and the like. However, since all Aerographer's Mates process constant pressure charts which have these various features analyzed, they should be familiar with the symbols used to represent the features on both the original chart and the charts prepared for transmission by facsimile. Table 11-2 summarizes all the features of upper air charts in general and shows the standard markings to be used for the various elements.

Analysis Technique

As with the surface chart, constant pressure chart analysis should consist of the following four steps:

1. Before accomplishing anything else, review the previous charts for the PAST HISTORY of the constant pressure surface in question. As with the surface analysis, first make any corrections to the previous analysis that may be necessary due to late or additional reports. Trace the pertinent features of this past history onto the chart being analyzed. In many units the past history is traced to the lastest chart before it is even plotted.

2. Preliminary analysis. Before actually drawing a constant pressure chart, it should first be surveyed visually to get the general overall idea of the windflow and the height pattern that exists.

3. Basic analysis. After the chart has been visually checked and the general overall idea of the windflow and height pattern noted, the actual analysis may be started.

First, sketch the contours lightly. Contours nearly always parallel the wind direction. As with isobars, contours are close together when the wind speed is strong and far apart when the wind speed is weak.

Next, sketch the fronts and trough lines. After sketching the fronts and trough lines, sketch the isotherms and then any other required isopleths.

4. Final analysis. When the basic analysis is complete, the final analysis may be made. Smooth the contours and draw them heavily. Label all contours with their correct values Draw the fronts and trough lines. Fronts are indicated in the same manner as on the surface chart. Troughs are indicated as dashed brown lines. Smooth the isotherms and label each with the representative temperature value. Smooth miscellaneous isopleths and label each with the appropriate value. Label the high and low height areas.

NOTE: For ease in interpretation, the isotherms drawn on the 700-mb chart in figure 11-21 are dashed lines.

A summary of the recommended procedures for analyzing a constant pressure chart is as follows:

1. Study past history; trace it on the current chart.
2. Sketch the contours lightly.
3. Sketch the fronts or troughs.
4. Smooth the contours and draw them heavily. Label all contours with their correct values, and in the correct manner.
5. Draw the fronts or troughs heavily.
6. Sketch the isotherms.
7. Draw the isotherms heavily and label them correctly.
8. Sketch miscellaneous isopleths lightly.
9. Draw miscellaneous isopleths heavily and label them correctly.
10. Label the high and low height areas.

OCEANOGRAPHIC CHARTS

As with other meteorological charts, you must first plot the oceanographic parameters before an oceanographic chart can be analyzed. The following paragraphs briefly discuss some of the plotting procedures involved in oceanographic charts.

Plotting Sea Conditions

The state of the sea is of utmost importance in the preparation of ASWEPS charts, as it denotes ship behavior and sonar-quenching characteristics which are of considerable interest when planning ASW and various other operations.

Sea condition charts may be plotted daily, utilizing data available over existing radio and teletype networks. One important source of data

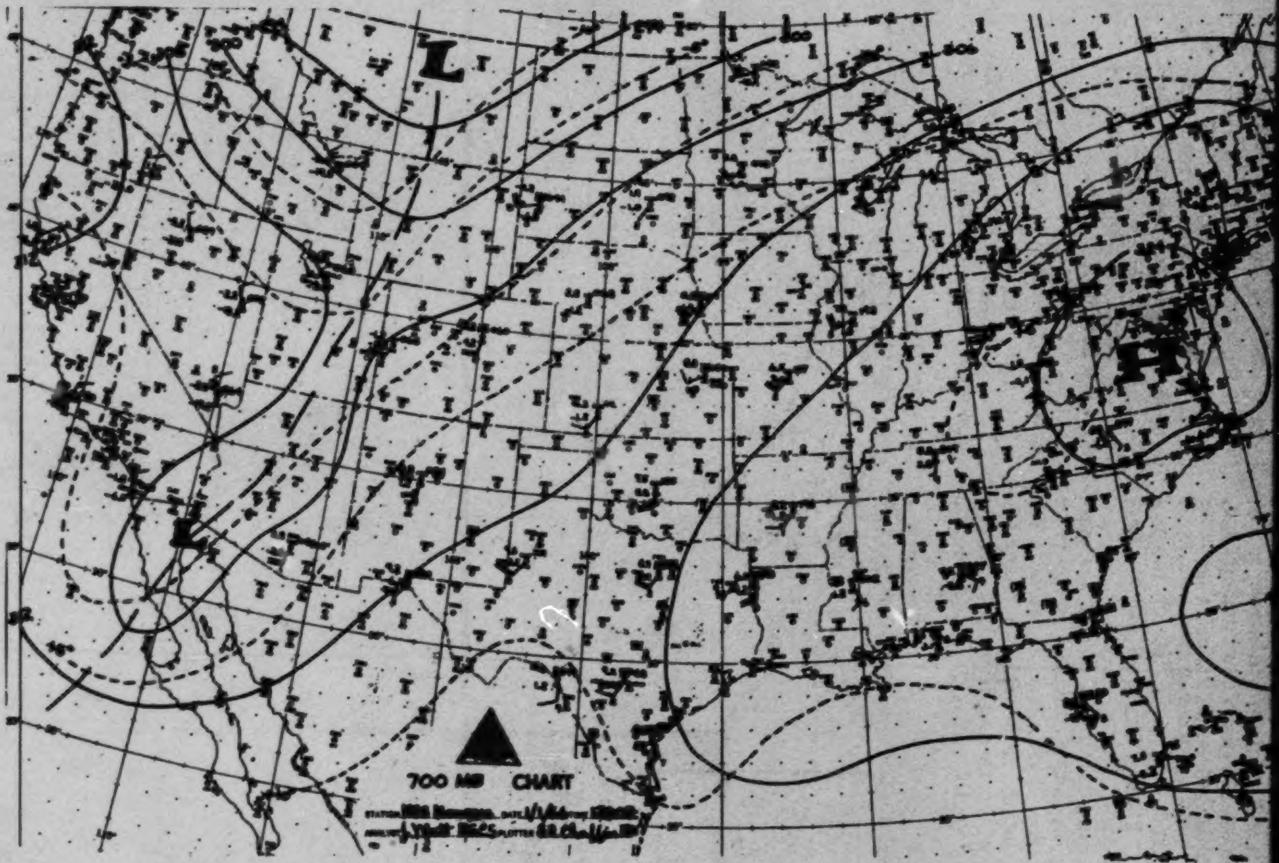

L
L
H
700 MB CHART

Figure 11-21.—Constant pressure chart (700-mb).

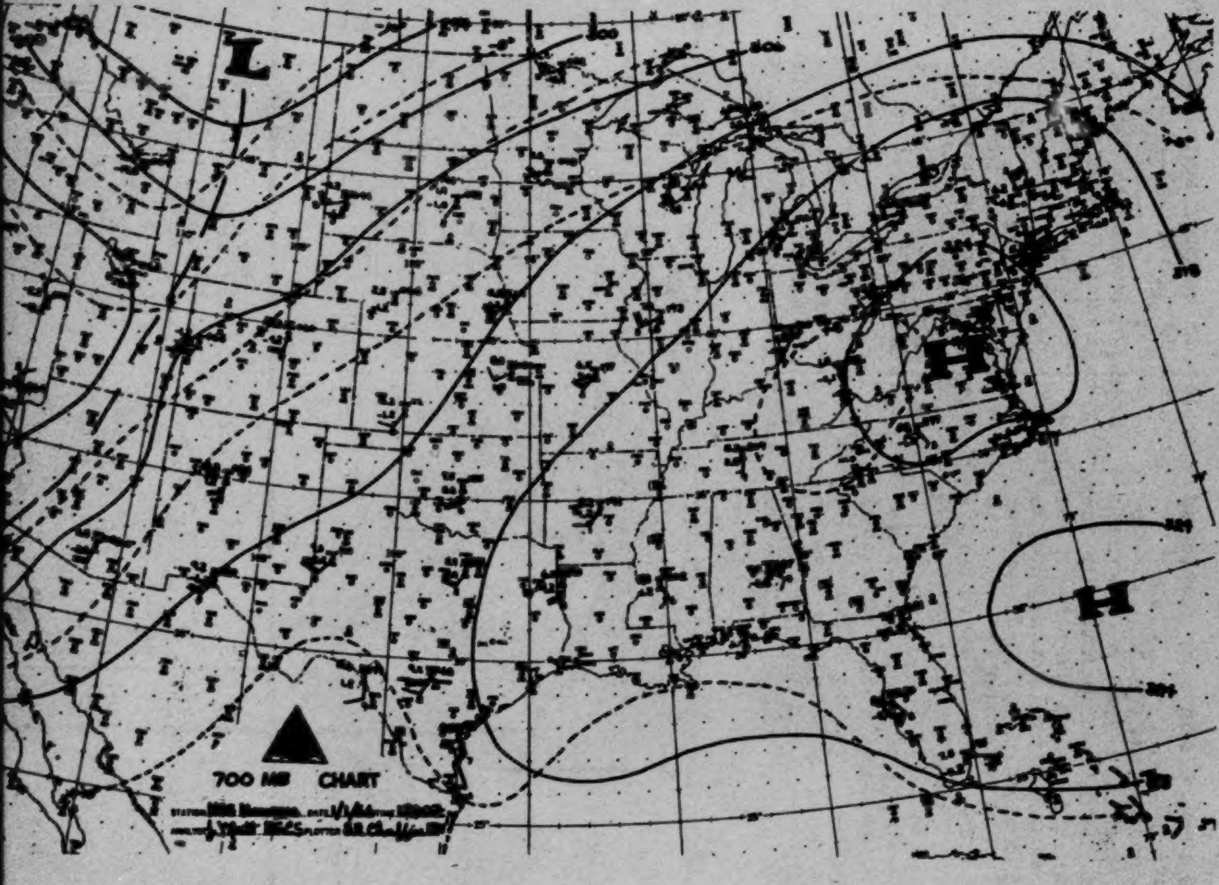

L
H
H
700 MB CHART

Figure 11-21.—Constant pressure chart (700-mb).

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is the routine synoptic ship report received four times daily.

The ship synoptic code (FM 21.( )) is discussed in the previous chapter. The first three groups provide information to locate the reporting station (ship) in time and space on the sea condition chart. Of the remaining groups, group $3P_WP_WH_WH_W$ and $d_Wd_WP_WH_WH_W$ provide information for plotting wind wave and swell wave height, period, and direction on the sea condition chart. Figure 11-22 is an example of a plotted sea condition chart.

The surface wind is plotted on the sea condition chart in the same manner as it is on the synoptic surface chart. The direction of the sea is plotted using an arrow for direction (commencing at 0° North and increasing clockwise). The arrow points TOWARD the direction the sea is moving. Period and height are plotted to the right of the arrow.

Swell is plotted to the right of the sea plot, using an identical procedure. The lower right-hand corner of figure 11-22 shows plot containing both sea and swell. In this example the surface wind is from 320 degrees with a speed of 35 knots. The sea is from 320 degrees with a 5-second period and a height of 7 meters. (See NA50-1P-11 for related code tables.) The swell is from 340 degrees with a 4-second period and a height of 2 meters.

Plotting Sea Surface Temperatures

Sea surface temperatures are the most easily obtainable oceanographic parameters and are

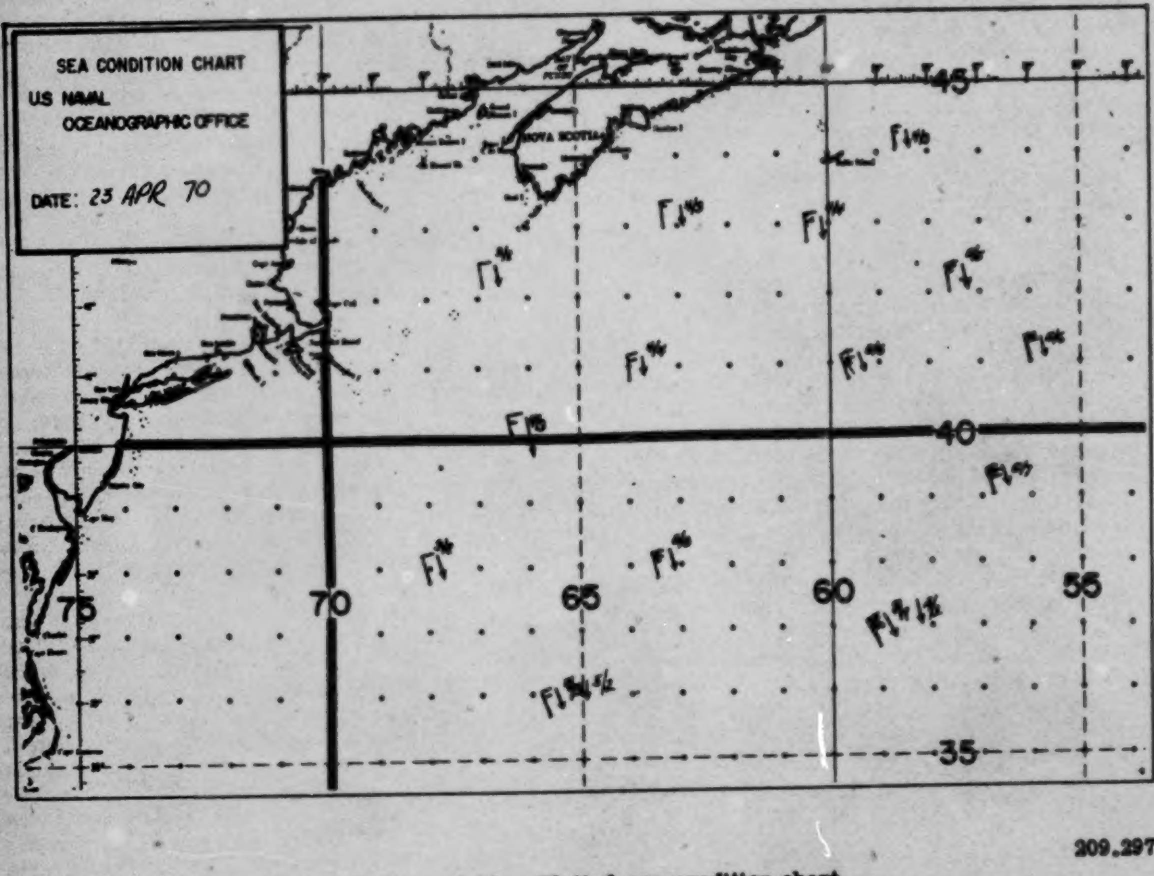

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Figure 11-22.—Plotted sea condition chart.

therefore most frequently received. It is extremely important that the sea surface temperature (SST) be obtained and plotted as accurately as possible, since the SST analysis may be used as a guide when analyzing charts compiled of less frequently received data. Erroneous values and incorrect positioning of correct values can change the entire character of the SST analysis and all of the resultant products. A single day's collection of reports is usually not sufficient for the preparation of a SST regional analysis. It is usually necessary to plot an accumulation of several days' data on the same chart. The exact number of days to be used will vary dependent upon the size of the area to be considered, the number of reports received daily, and the characteristics of the forecast area.

Although most temperatures are observed, recorded and transmitted in degrees Celsius they are analyzed in degrees Fahrenheit, and must therefore be converted prior to plotting them on the SST chart.

Many errors in the transmitted messages can be corrected by the plotter. Erroneous values are generally the result of encoding errors or transmission garbles.

Plotting Mixed/Sonic Layer Depth Charts

The Mixed Layer Depth (MLD) refers to the depth to which the surface layer of water has been mixed through convective and/or mechanical mixing processes. Sonic Layer Depth (SLD) refers to the depth of maximum sound velocity in the upper 1500 feet of the ocean.

A plus (+) sign following the plotted layer depth value indicates the MLD may be at a greater depth than the value plotted. This would occur if no reported level had a temperature at least 2°F colder than the reported sea surface temperature and the maximum depth of the sounding is plotted as the MLD.

If the reported temperature at the layer depth is warmer than the SST, a "P" is plotted after the layer depth value to indicate a positive temperature gradient from the surface to the layer depth.

In some cases both a "P" and a "+" are plotted. In this instance the P precedes the +; for example 240P+.

Plotting Gradients

Although SST and LD charts present valuable information for computing sonar ranges, etc., additional and/or more precise determinations of value to the forecaster require knowledge of the thermal gradients in the water column. Analyzed plots of the temperature gradient (rate of change) in the 100 feet of water immediately below the MLD provide the forecaster with an indication of the degree of stability of the water column and the degree of persistence of the MLD.

Oceanographic Analysis

By the time the Aerographer's Mate has advanced to Aerographer's Mate 3 and is in the process of advancing to Aerographer's Mate 2, he should realize that a correct analysis is amoung the most important tools in forecasting. There are many different types of analyses. Those presented in the following paragraphs are designed to assist in the preparation for advancement to Aerographer's Mate 2. However, the Aerographer's Mate should attempt to acquaint himself with as many of the other types of analyses as he can, if he is to acquire a more comprehensive understanding of the meteorological-oceanographic relationship and its application towards the problems he will eventually encounter in forecasting.

Many of the same procedures discussed for meteorological charts in this chapter also apply when preparing the oceanographic analysis.

SEA SURFACE TEMPERATURE (SST) ANALYSIS.—The analysis of the sea surface temperature (SST) chart, in the absence of computer products, is usually accomplished by using a synoptic approach similar to that used for meteorological charts. This method is subjective in that different analysts will draw somewhat different conclusions from the same set of data. However, as long as the same general rules are adhered to the end product will be approximately the same.

One of the more important rules that the analyst of the SST data should keep in mind is that warm currents generally move more rapidly than cold currents. This is true because cold water will contract, causing the surface to have a lower level than warm water. This allows the warm water to flow down hill as it moves northward. Also, since the molecules in the warm water are farther apart due to the higher temperature, the warm water is lighter (less viscous) and therefore able to move more rapidly.

When commencing the SST, the approach is similar to the meteorological analysis of air masses. In this case, the determination is the orientation of the water masses. Since the water masses in an area are dependent upon current structure, consideration must also be given to this element.

Each area of the oceans has its local characteristics such as bottom topography, current flow, prevailing winds, etc. Since it would be confusing to attempt to describe an analysis of all the oceans at once, this discussion will be confined to the Western North Atlantic area. However, the same general rules apply in other areas as well, with modification dependent on the local characteristics of the area.

CONSIDERATIONS RELATING TO SST ANALYSIS.—The western North Atlantic is dominated by a large, clockwise rotating water mass, the Sargasso Sea, with the Gulf Stream flowing along the perimeter as a restriction to the outflow of water from the area.

Characteristics of the Gulf Stream.—The Gulf Stream flows from a region of excessive evaporation and surface heating into one of excessive fresh water (precipitation and thawing ice) and surface cooling. Consequently, the Gulf Stream waters show decreasing salinity with depth; and upon moving northward, they show increasing instability as a result of convective mixing. These factors tend to produce more pronounced velocity structures in warm water currents since by their nature they exhibit deeper mixing. Cold currents, such as the Labrador waters, tend to become more stable as they move south since, in addition to the characteristic salinity increasing with depth, surface heating adds to their stability. These characteristics prevent deep mixing, however, so that the cold currents are more poorly defined with depth.

One characteristic feature which exerts considerable influence on the water structure is the "meanders" in the Gulf Stream. Although the definition of meander is "to wander aimlessly," the meanders of the Gulf Stream, primarily due to bottom topography, are quite persistent.

As the meanders continue to occur, momentum forces some of the water up over colder more dense water to the north causing many tongue like protrusions. This configuration is evident in the SST analysis illustrated in figure 11-23. This overriding effect also occurs to the south; however, it is not so pronounced.

Meanders in the Gulf Stream are also affected by fluctuations in the wind field. For example, if the Bermuda High is located south of its normal position, there is a resulting increase in the trade winds. This in turn causes an increase in the Gulf Stream velocity.

The rate of the meander motion may be on the order of 10 to 15 nautical miles per day but is often much slower.

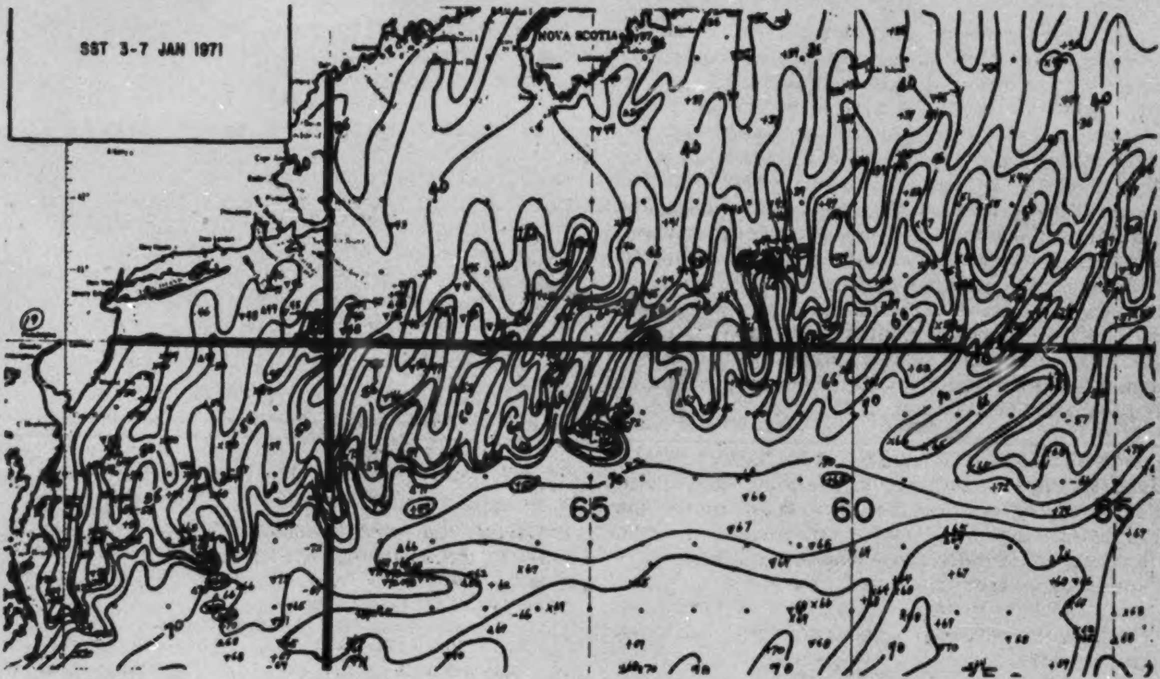
Seasonal Temperature Variations of the Western North Atlantic.—During the summer season the sea surface temperatures of the Gulf Stream usually run 75°F or higher, and the Sargasso Sea surface temperatures are in excess of 80°F.

During the winter season the Gulf Stream surface temperatures are normally in the 70° to 80°F range and those in the Sargasso Sea generally 70°F or greater.

From the preceding discussion it is apparent that the temperatures of the surface water of the Sargasso Sea and the Gulf Stream normally do not vary to as great an extent as do other areas adjacent to the Gulf Stream. For example, water to the north of the Gulf Stream, originating in the Labrador Sea or farther north in the Arctic and moving southward will create comparatively large temperature differences over short distances. Therefore, the analysis will show strong horizontal temperature gradiants along the northern edge of the Gulf Stream. The contrast between the cold Labrador and the warm Gulf Stream water creates a narrow transition zone called the north wall, which is similar to a front between air masses.

Although the temperature gradients along the north wall are strong during all seasons, they are somewhat stronger during the winter. The north wall (boundary between Gulf Stream and Labrador water) is usually outlined by the 68°F isotherm in September in the Cape Hatteras area, with these temperatures decreasing to the east. The north wall of the Gulf Stream is usually not identifiable east of 60° west longitude.

The seasonal sea surface temperatures of the counter current range from 75° to 77°F in the summer (occasionally higher in late summer) to 60° to 69°F during the winter season.



209.331

Figure 11-23.—Sea surface temperature analysis of western North Atlantic.

Analysis Techniques.—In most areas in which the AG will work, he will have available to him recent SST analyses in the form of charts or RATTGRAPHIC teletype messages.

These charts will provide a history to follow when performing analysis. Through reference to these history charts and a current synoptic chart, the task of analyzing the SST chart is simplified to a considerable degree. This is due to the fact that the oceans show considerable conservatism and change gradually. Even in areas where two major currents are adjacent, only small orderly changes take place. This tendency of the oceans to change at a gradual pace must be constantly kept in mind. Any sudden changes in temperature patterns should be closely examined and their cause determined as to whether the change is real or in error.

A few of the more pertinent rules of behavior of the oceans to be considered as you prepare the SST analysis are as follows:

1. Look for a complex analysis of tongue-like protrusions on the northern edge of the Gulf Stream such as those indicated in figure 11-23. This same configuration will probably be evident for any of the northward flowing major currents.

2. Watch for rapid changes in the horizontal temperature gradient to the north (i.e., tight gradient).

3. A much less complex pattern will characterize the Gulf Stream or other major currents on the southern side.

4. Cold tongues will generally be orientated toward the south or southwest (from a source in the north or northeast). Warm tongues will be orientated towards the north or northeast (from the source of warm water).

5. The Gulf Stream or other major currents can be expected to be continuous and should not be segmented or cut into by cold tongues.

6. Although isolated pools of water do exist, they are rare. If they do occur, they will last only a short time and therefore probably not show up on composite charts.

With the preceding rules in mind, the following procedure is suggested for completing the SST analysis: Place the plotted chart over the history chart. Next, locate the most predominant or most persistent feature on the historical chart (Gulf Stream, Kuroshio Current, etc.). If there are no major features, start in the area of the most dense data. This area or feature is outlined with a standard isotherm using the corresponding isotherm on the history map as a guide.

NOTE: Standard isotherm spacing is either 2°C or 5°F. However, in areas of weak horizontal gradients it may be necessary to analyze to the nearest 1° or even 1/2°.

If a report is noticed which does not fit and appears to be in error, it should be circled. In areas of few or no reports, copy the previous isotherms unless for some specific reason a change is indicated. When one isotherm is completed, take the next value in sequence and sketch it in while using history as a guide. Continue with this procedure until the chart is completed.

The final step in completing the sea surface temperature analysis is to harden in the isotherms, using either ink pen, felt tip pen, or soft pencil.

Label the chart type, date (if a composite chart, the date is the day of the latest data), and the name of the analyst.

SEA CONDITION ANALYSIS.—An important factor which must be considered in oceanographic forecasting is the physical condition of the surface of the sea. This refers to the height and direction of movement of the waves of which the surface is composed. The forecasting of these sea surface characteristics for fleet operations, rescue work, etc., is one of the more important responsibilities of the Aerographer's Mate.

As with any of the other parameters which describe the ocean environment, an analysis of the sea condition must be accomplished before a reliable forecast can be made.

Analysis Techniques.—Values of wave heights, periods and direction are plotted on the sea condition chart. Significant wave heights (average of 1/3 highest waves observed) in feet are indicated by solid isopleths and directions of wave trains are shown by arrows as indicated in figure 11-24.

The periods are not analyzed, primarily due to the inaccuracy of visual observations. These charts do not differentiate between sea and swell, but show the effective reported wave value height, whether the wave is sea, swell or a combination of both. An important disadvantage which must be remembered is that waves are not nearly as conservative as sea surface temperatures or layer depths, thus resulting in deterioration in the value of the chart over a relatively short period of time.

RADIOACTIVE FALLOUT

The radioactive fallout from nuclear weapons exploded on or near the surface of the earth creates serious hazards in large areas outside the area of structural damage. In predicting the fallout area, information must be at hand with respect to location of burst, the yield of the weapon, and the atmospheric wind structure. Except for experimental tests, only the last mentioned can be available before the detonation. The procedures explained in this chapter provide for the preparation of a generalized RADFO plot to be available for tactical purposes in reacting to low-yield and high-yield nuclear explosions.

In the event of a nuclear detonation, radiological fallout may be of great significance to the conduct of naval operations. This chapter provides Aerographer's Mates with the information necessary to enable them to determine areas which are potentially hazardous because of fallout following a nuclear explosion.

Procedures to be utilized by the operating forces of the Navy are contained in Nuclear Fall-Out Forecasting and Warning Organization ATP 25 (NAVY) (AIR) and, NAVWEASERVCOM INST. 3441.1.

FALLOUT MESSAGES

To aid in the evasion of fallout from nuclear explosions, two types of messages are disseminated to Naval units. One is used in case of an actual detonation of a nuclear device, while the second is a prediction type message that can be used for planning prior to a nuclear detonation. Both types are given in Table 11-3 along with their symbolic form and

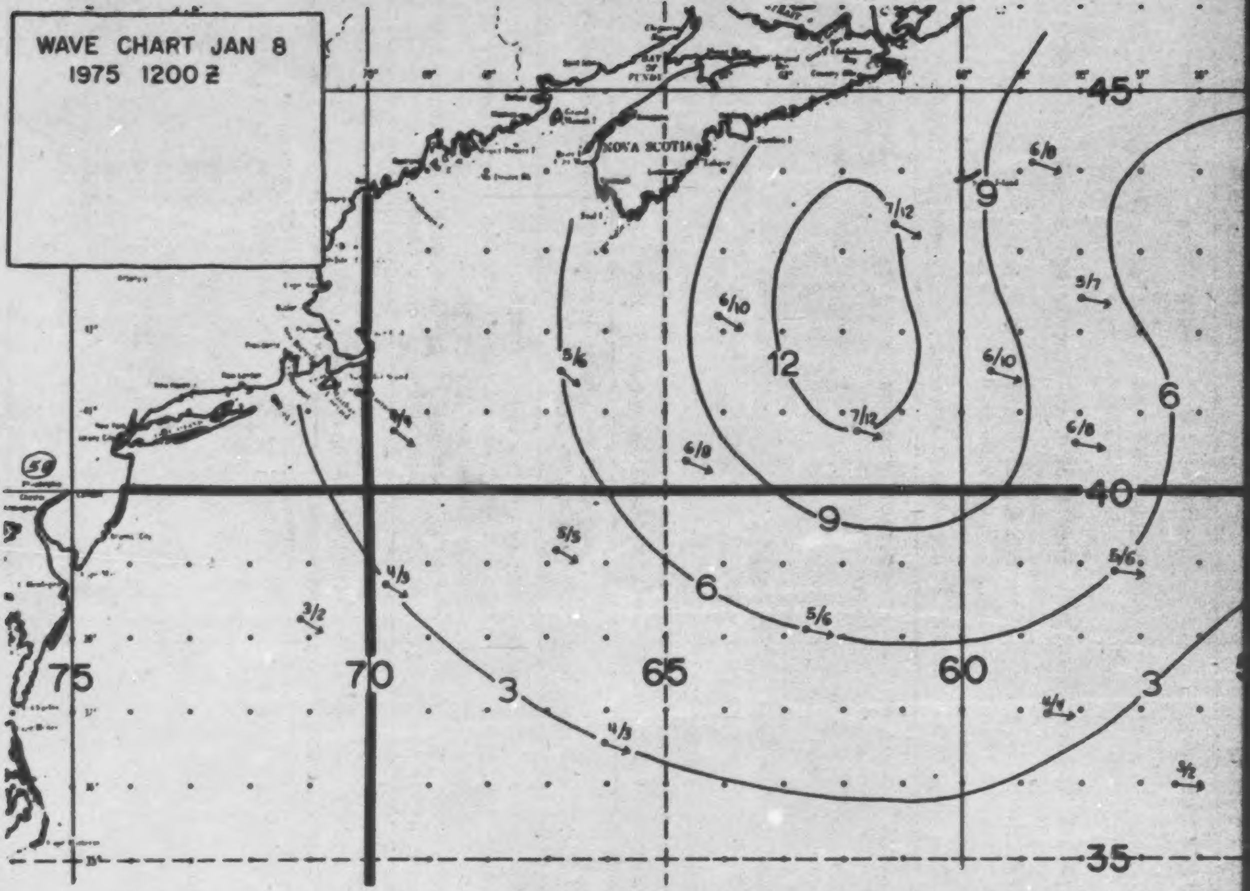

WAVE CHART JAN 8
1975 1200 Z
NOVA SCOTIA
BAY OF FUNDY
45
40
35
75
70
65
60
3
6
9
12
9
6
3
6/8
7/12
9
6/10
5/7
5/6
12
6/10
6
7/12
6/8
6/8
9
5/5
5/6
4/3
3/2
6
5/6
3
4/4
4/3
5/2

Figure 11-24.—Wave height analysis.

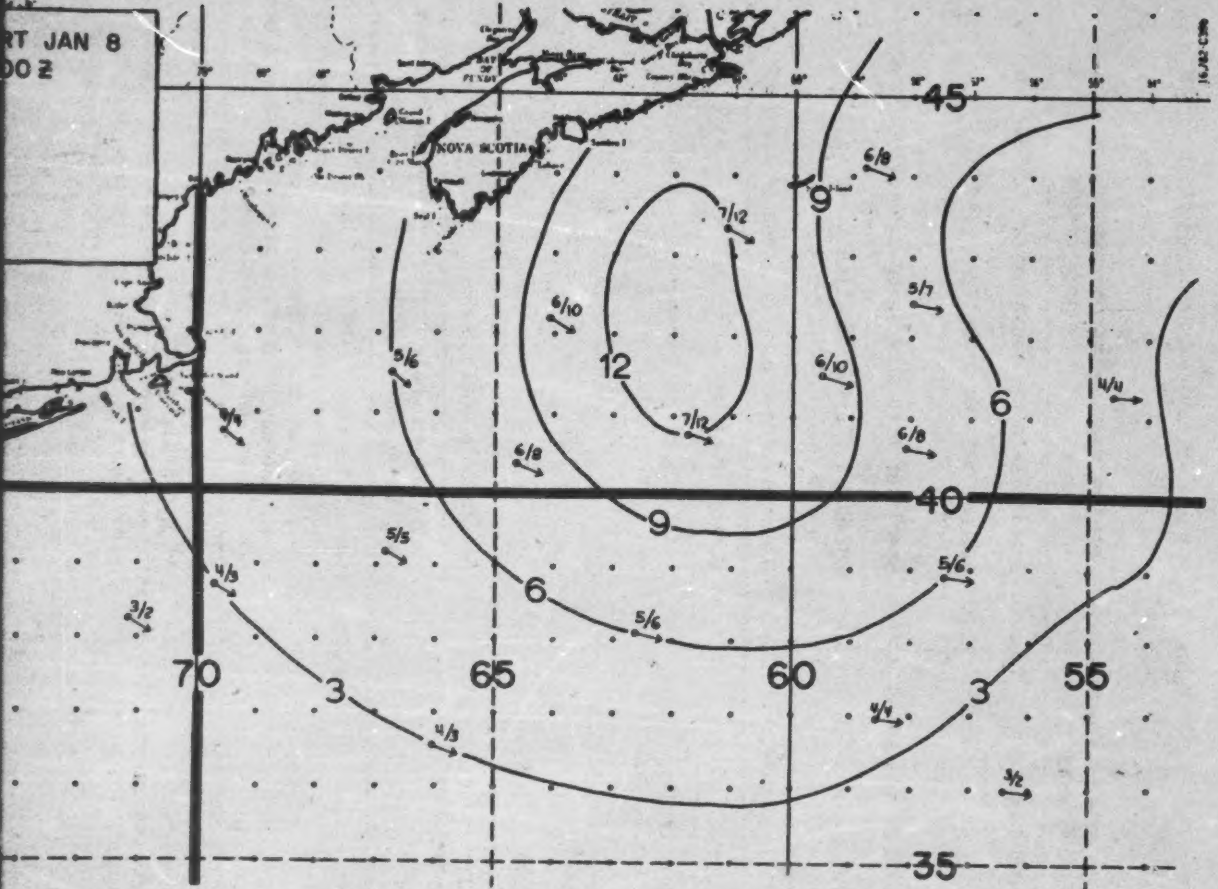

RT JAN 8
00 Z
NOVA SCOTIA
45
40
35
70
65
60
55
12
9
9
6
6
6
3
3
6/8
7/12
5/7
6/10
6/10
5/6
4/4
7/12
6/8
4/4
6/8
5/5
5/6
4/3
3/2
5/6
4/3
4/4
3/2

Figure 11-24.—Wave height analysis.

209.333

Table 11-3.—Navy radioactive fallout code and description

<table>
<tr><th>CODE GROUP</th><th>DESCRIPTION</th></tr>
<tr><td>FALLOUT WARNING

PRE-BURST PREDICTION</td><td>Specifies that a radiological fallout warning follows.
FALLOUT WARNING Atlantic/Pacific $QL_aL_aL_oL_o$ YYGG/YYYYY Tddss DDDDD
Specifies that a radiological fallout prediction follows.
PRE-BURST PREDICTION Atlantic/Pacific $QL_aL_aL_oL_o$ YYGGv $T_L$ddss DDDD $T_H$ddss DDDDD</td></tr>
<tr><td>ATLANTIC/PACIFIC</td><td>Ocean area covered. Only one of these groups is used.</td></tr>
<tr><td>Q</td><td>Octant of globe.
<table>
<tr><th>Code</th><th>Lat/Long</th><th>Hemisphere</th></tr>
<tr><td>0</td><td>0°-90°W</td><td>North</td></tr>
<tr><td>1</td><td>90°W-180</td><td>North</td></tr>
<tr><td>2</td><td>180°-90°E</td><td>North</td></tr>
<tr><td>3</td><td>90°E-0°</td><td>North</td></tr>
<tr><td>5</td><td>0° -90°W</td><td>South</td></tr>
<tr><td>6</td><td>90°W-180°</td><td>South</td></tr>
<tr><td>7</td><td>180° -90°E</td><td>South</td></tr>
<tr><td>8</td><td>90°E-0°</td><td>South</td></tr>
</table></td></tr>
<tr><td>L_aL_a</td><td>Latitude in whole degrees</td></tr>
<tr><td>L_oL_o</td><td>Longitude in whole degrees (hundreds digit is omitted for longitudes 100°- 180°)</td></tr>
<tr><td>YY</td><td>Day of the month (GMT)
a. 01 means the first day of the month, 02 means the second day of the month, etc.
b. The day is defined with reference to Greenwich mean time and not local time.</td></tr>
<tr><td>GG</td><td>Time of burst or time of beginning of period of prediction in whole hours GMT.</td></tr>
<tr><td>Gv</td><td>Period of time covered by the forecast
<table>
<tr><th>Code</th><th>Prediction Valid For</th></tr>
<tr><td>1</td><td>3 HRS</td></tr>
<tr><td>2</td><td>6 HRS</td></tr>
<tr><td>3</td><td>9 HRS</td></tr>
<tr><td>4</td><td>12 HRS</td></tr>
<tr><td>5</td><td>18 HRS</td></tr>
<tr><td>6</td><td>24 HRS</td></tr>
<tr><td>7</td><td>48 HRS</td></tr>
<tr><td>8</td><td>72 HRS</td></tr>
</table></td></tr>
</table>

Table 11-3.—Navy radioactive fallout code and description—Continued

CODE GROUP	DESCRIPTION
T, T_L, T_H	Designation of applicable template for actual burst (T), Low Yield (T_L), or High Yield (T_H). Code — Template 1 — ALPHA 2 — BRAVO 3 — CHARLIE 4 — DELTA 5 — ECHO 6 — FOXTROT
dd	Direction of effective fallout wind measured in tens of degrees clockwise from true north.
ss	Fallout wind speed in knots.
YYYYY	Yield of weapon in kilotons (KT). This will always be coded as a five-figure group. (i.e., 00001 = 1KT, 10000 = 10,000 KT = 10 Megaton (MT).
DDDDD	The distance in nautical miles from surface zero measured along the fallout axis to the 200r contour. The 200r contour represents a total radiation dose of 200 roentgens (r) to 48 hours after detonation. This can be determined from figure 10-58 of this manual.

NOTES: 1. When two or more areas are included in a fallout prediction message, the heading should only be used at the beginning of the collective. The coded groups may be repeated as necessary.

2. For pre-burst prediction, low-yield will be defined as yield of a 20KT weapon and high yield will be that of a 5 MT weapon.

breakdown of the individual symbols. The templates referred to in this table are depicted in figures 11-25 through 11-27.

RADIOACTIVE FALLOUT DIAGRAM

The RADFO diagram is made available to operational commands in order to provide the basis for immediate decisions, with respect to evasive action, evacuation, radiological countermeasures, etc., following a nuclear explosion.

The information contained in the coded message is translated into geographical terms by means of an overlay.

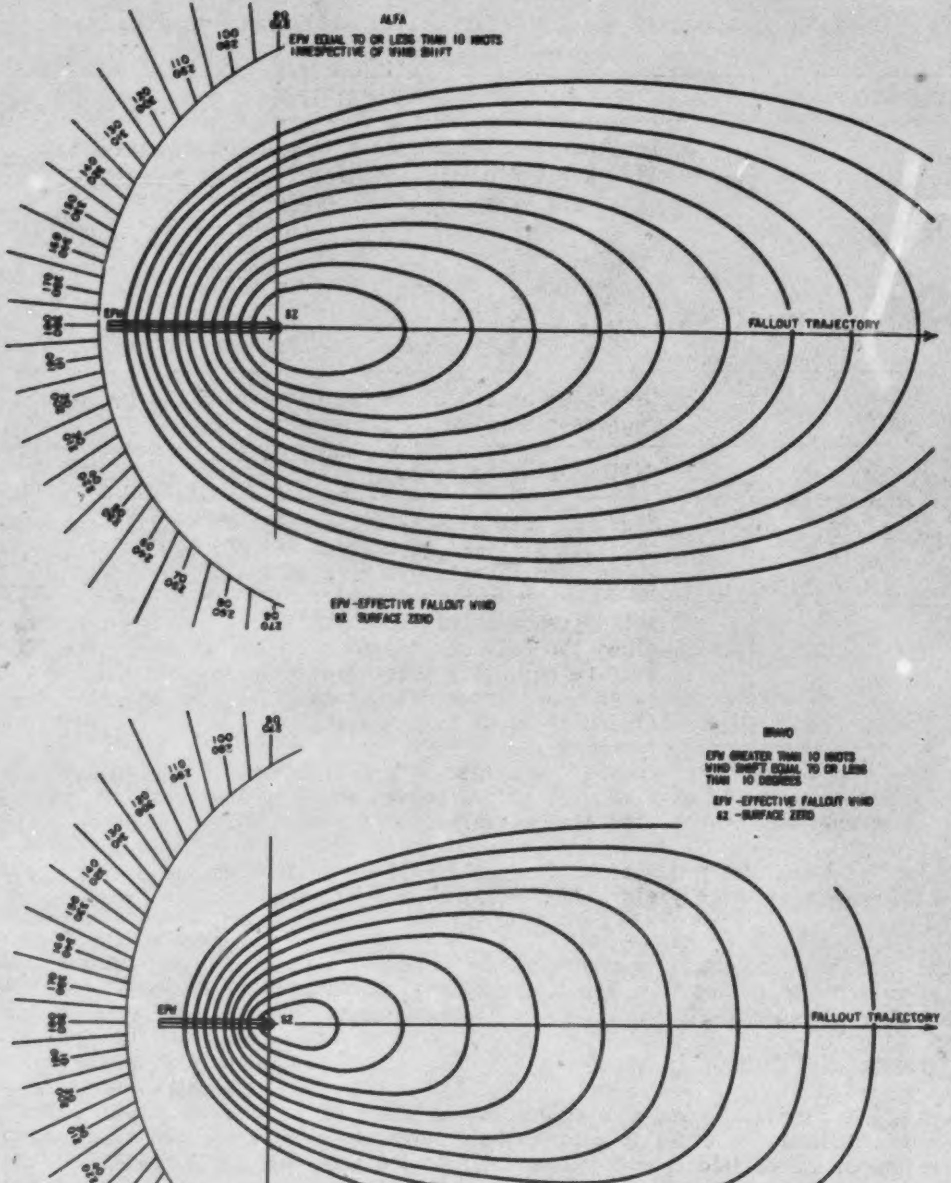
Since the overlay will be used frequently, it is suggested that it be prepared ahead of time for RADFO use by putting certain permanent markings on it. For convenience, the permanent markings are inscribed on the reverse side of the overlay and covered with Scotch tape, so that temporary marks can be wiped off without disturbing the permanent ones. Use a sheet of transparent plastic large enough to cover approximately 500 miles by 300 miles on the base map to be used. In one corner print the following legend, using MIRROR script.

RADFO Overlay

Valid time________________________

Location________________________

Map scale________________________

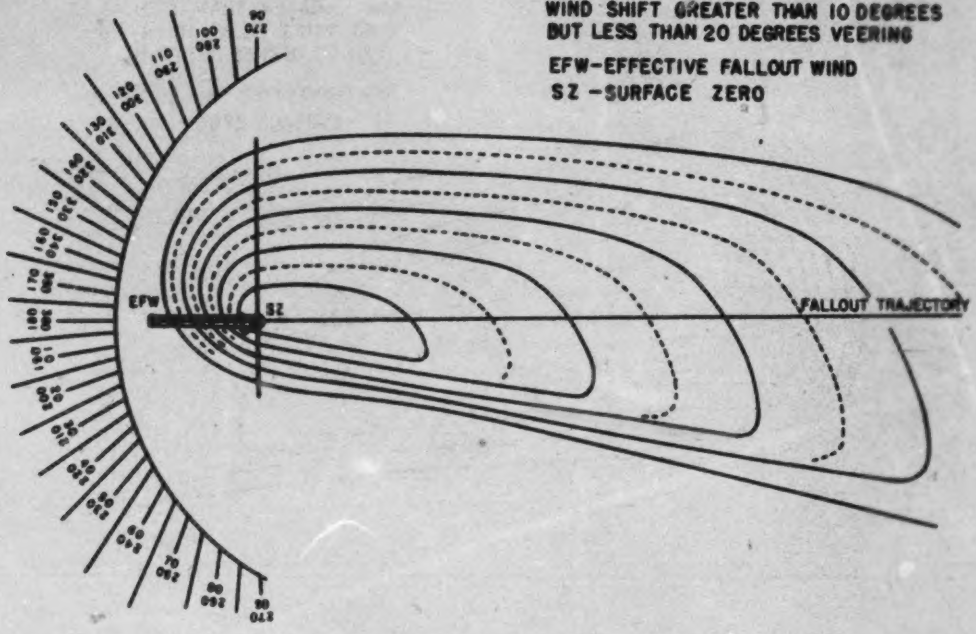

ALFA
EFW EQUAL TO OR LESS THAN 10 KNOTS
IRRESPECTIVE OF WIND SHIFT
EFW
SZ
FALLOUT TRAJECTORY
EFW -EFFECTIVE FALLOUT WIND
SZ SURFACE ZERO
100
110
BRAVO
EFW GREATER THAN 10 KNOTS
WIND SHIFT EQUAL TO OR LESS
THAN 10 DEGREES
EFW -EFFECTIVE FALLOUT WIND
SZ -SURFACE ZERO
EFW
SZ
FALLOUT TRAJECTORY

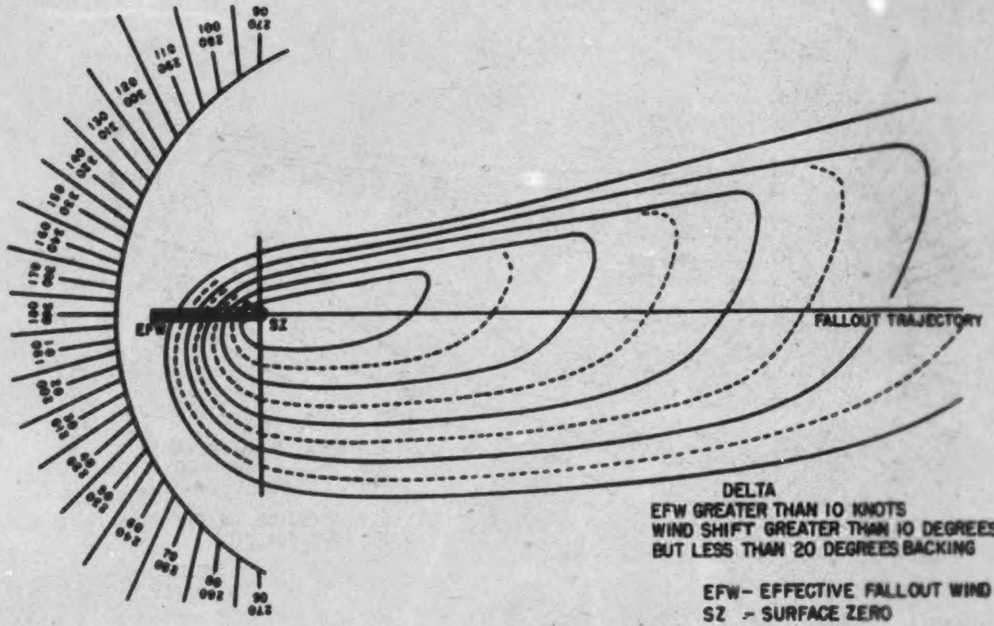
209.31

Figure 11-25.—Templates ALFA and BRAVO.

CHARLIE
EFW GREATER THAN 10 KNOTS
WIND SHIFT GREATER THAN 10 DEGREES
BUT LESS THAN 20 DEGREES VEERING

EFW-EFFECTIVE FALLOUT WIND
SZ -SURFACE ZERO


EFW
SZ
FALLOUT TRAJECTORY
90 270
100 280
110 290
120 300
130 310
140 320
150 330
160 340
170 350
180 360
190 10
200 20
210 30
220 40
230 50
240 60
250 70
260 80
270 90

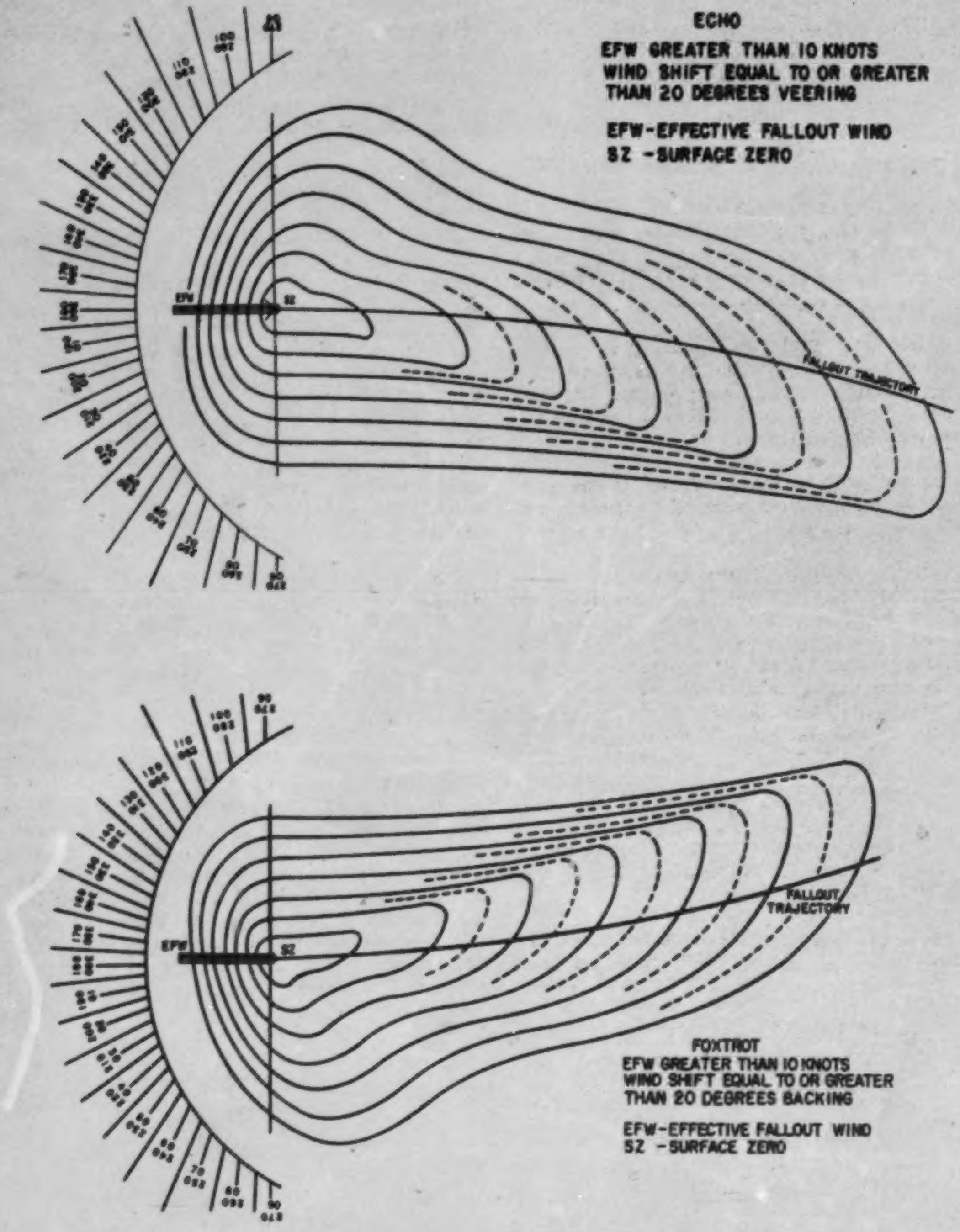

EFW
SZ
FALLOUT TRAJECTORY
90 270
100 280
110 290
120 300
130 310
140 320
150 330
160 340
170 350
180 360
190 10
200 20
210 30
220 40
230 50
240 60
250 70
260 80
270 90

DELTA
EFW GREATER THAN 10 KNOTS
WIND SHIFT GREATER THAN 10 DEGREES
BUT LESS THAN 20 DEGREES BACKING

EFW- EFFECTIVE FALLOUT WIND
SZ - SURFACE ZERO

209.33

Figure 11-26.—Templates CHARLIE and DELTA.


ECHO
EFW GREATER THAN 10 KNOTS
WIND SHIFT EQUAL TO OR GREATER THAN 20 DEGREES VEERING
EFW-EFFECTIVE FALLOUT WIND
SZ -SURFACE ZERO
EFW
SZ
FALLOUT TRAJECTORY
EFW
SZ
FALLOUT TRAJECTORY
FOXTROT
EFW GREATER THAN 10 KNOTS
WIND SHIFT EQUAL TO OR GREATER THAN 20 DEGREES BACKING
EFW-EFFECTIVE FALLOUT WIND
SZ -SURFACE ZERO

209.35

Figure 11-27.—Templates ECHO and FOXTROT.

Cover the legend with Scotch tape. When the overlay is turned over, the data in the legend can be entered in grease pencil for the particular fallout diagram to be plotted.

The RADFO diagram consists basically of two somewhat elliptic contour lines as follows:

1. Low-Yield Explosion. A RED contour line is used to indicate the limits of an area where radioactive fallout may be expected to exceed 200 roentgens in 48 hours when a low-yield nuclear weapon is exploded.

2. High-Yield Explosion. A BLACK contour line is used to indicate the limits of an area where radioactive fallout may be expected to exceed 200 roentgens in 48 hours when a high-yield nuclear weapon is exploded.

3. Explosion of Unknown Yield. If there is no available information relative to the amount of yield, use the black (high-yield) contour.

4. Fallout Advance. Fallout does not occur simultaneously over the entire area outlined on a RADFO diagram. It begins in the vicinity of the burst and advances as a function of time and the wind speed. If desired, the area primarily affected by fallout actively precipitating at a specified time after the explosion can be determined and marked on the overlay.

Plotting Procedure

The following steps should be followed in constructing a RADFO diagram on the overlay:

1. From the coded message, select the first geographic point for which fallout forecast data are to be plotted.

2. Select the template indicated for the low-yield trajectory from this point.

3. Mark a small x on the overlay and label SZ (surface zero).

4. Using a protractor, plot the effective fallout wind through the SZ. This is the fallout axis.

5. Along the fallout axis, plot the downwind distance from SZ.

6. Select the appropriate template. Place SZ of the overlay over SZ of the template. Select the template contour which crosses the axis nearest the downwind distance. Trace this contour in the appropriate yield color.

The procedure outlined above can also be repeated on another overlay for a second geographic location.

Fallout does not occur simultaneously over the entire area indicated on the overlay. It starts in the vicinity of surface zero and moves downwind along the trajectory of the fallout pattern. The rate at which it advances is a function of time and the wind speeds of the various layers of the atmosphere through which the radioactive particles fall. For fallout purposes, these winds are treated in a manner analogous to ballistic winds. Wind speeds and directions in the various layers are weighted and averaged, thereby obtaining a single wind speed and direction which is called the Effective Fallout Wind (EFW).

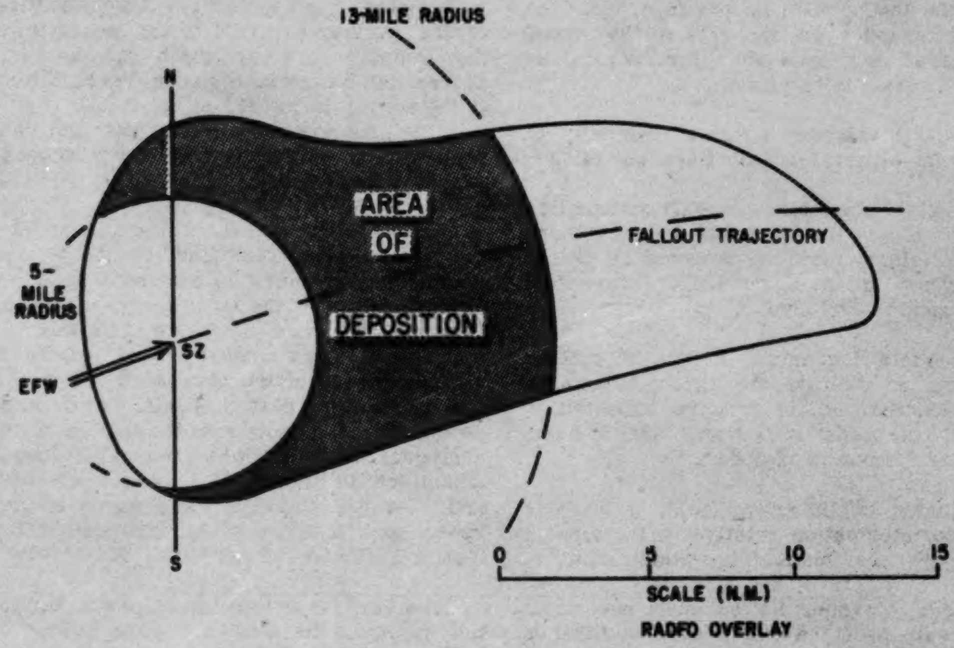
The RADFO overlay may be marked to show the approximate zone in which fallout occurs at a specific time following the burst, as shown in figure 11-28. Procedures for determining this zone can be found in ATP-25.

Use of the Overlay

Place the overlay on the maneuvering board or on the map or chart for which it was designed, so that SZ falls on the center of the board or on the map location of the point of detonation. Orient the overlay so that the NORTH or SOUTH (as appropriate) parallels the north-south axis of the maneuvering board or chart, and is directed in the proper sense to correspond with the protractor scale used. The contour lines indicate the forecast fallout areas with respect to geographic positions.

RADIOACTIVE FALLOUT COMPUTATIONS

If RADFO information is not available, it must be prepared locally. The procedures outlined in Nuclear Fall-Out Forecasting and Warning Organization ATP 25 (NAVY) (AIR), describe the various methods used to prepare a RADFO plot or message. Depending upon the facilities available, the requirements, and the data availability, one of several procedures may prove to be more suitable than another.



209.358

Figure 11-28.—A portion of diagram showing the area of deposition.

SKEW-T DIAGRAM

The SKEW-T Diagram is the standard thermodynamic chart in use throughout the Navy today. This diagram is a graphic representation of pressure, density, temperature, and moisture, in a manner that the basic atmospheric energy transformations are visually depicted. A unit of area on the diagram represents a specific quantity of energy. This diagram when plotted with the various meteorological elements, received from an upper air sounding, presents a vertical picture of the atmospheric conditions present at the time of observation and allows for computations of various parameters required by forecasters.

DIAGRAM DESCRIPTION

The standard SKEW-T Diagram for general use is a large multi-colored (brown, green, and black) chart with numerous scales and graphs superimposed upon each other. (See figure 11-29.) The five basic lines on the chart are as follows:

1. ISOBARS-Horizontal, solid, brown lines, spaced logarithmically for 10-mb intervals. Pressure-value labels are printed at both ends and in the center of isobars for each 50-mb interval. The upper portion of the chart from 400 to 100 mb is also used for pressure values from 100-25 mb. Labels for the latter range are printed in brackets at the ends of the appropriate isobars. (See figure 11-30.)

2. ISOTHERMS-These are the straight, solid, brown lines, sloping from the lower left to the upper right, with the spacing equal throughout the diagram. They are labeled for 5°C intervals, with alternate 10°C temperature bands tinted green. A Fahrenheit temperature scale is printed along the bottom edge of the chart to coincide with the appropriate isotherms. (See figure 11-31.)

3. DRY ADIABATS-The slightly curved, solid brown lines, that slope from the lower right

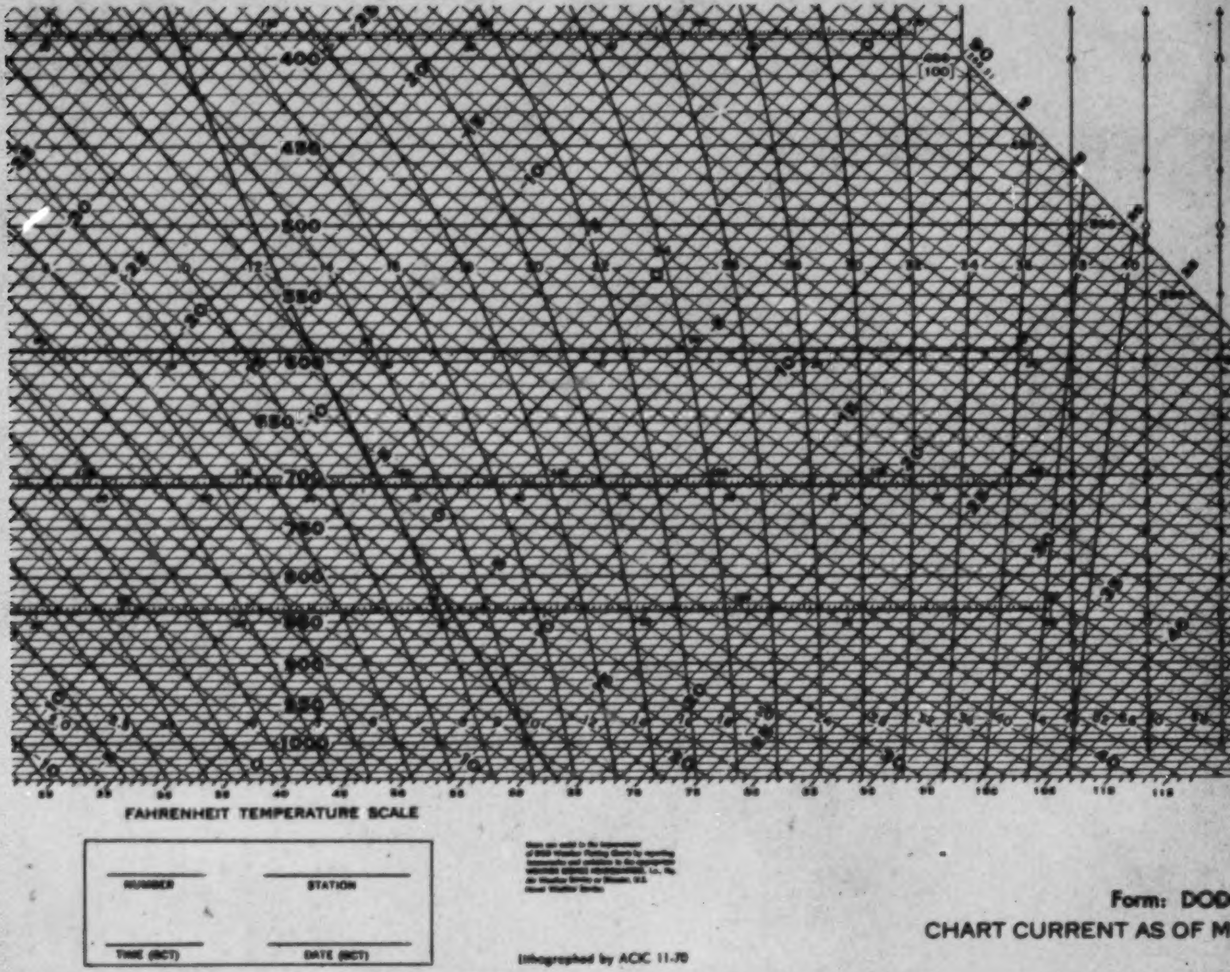


Figure 11-29.—A portion of a small scale SKEW-T Log P Diagram.

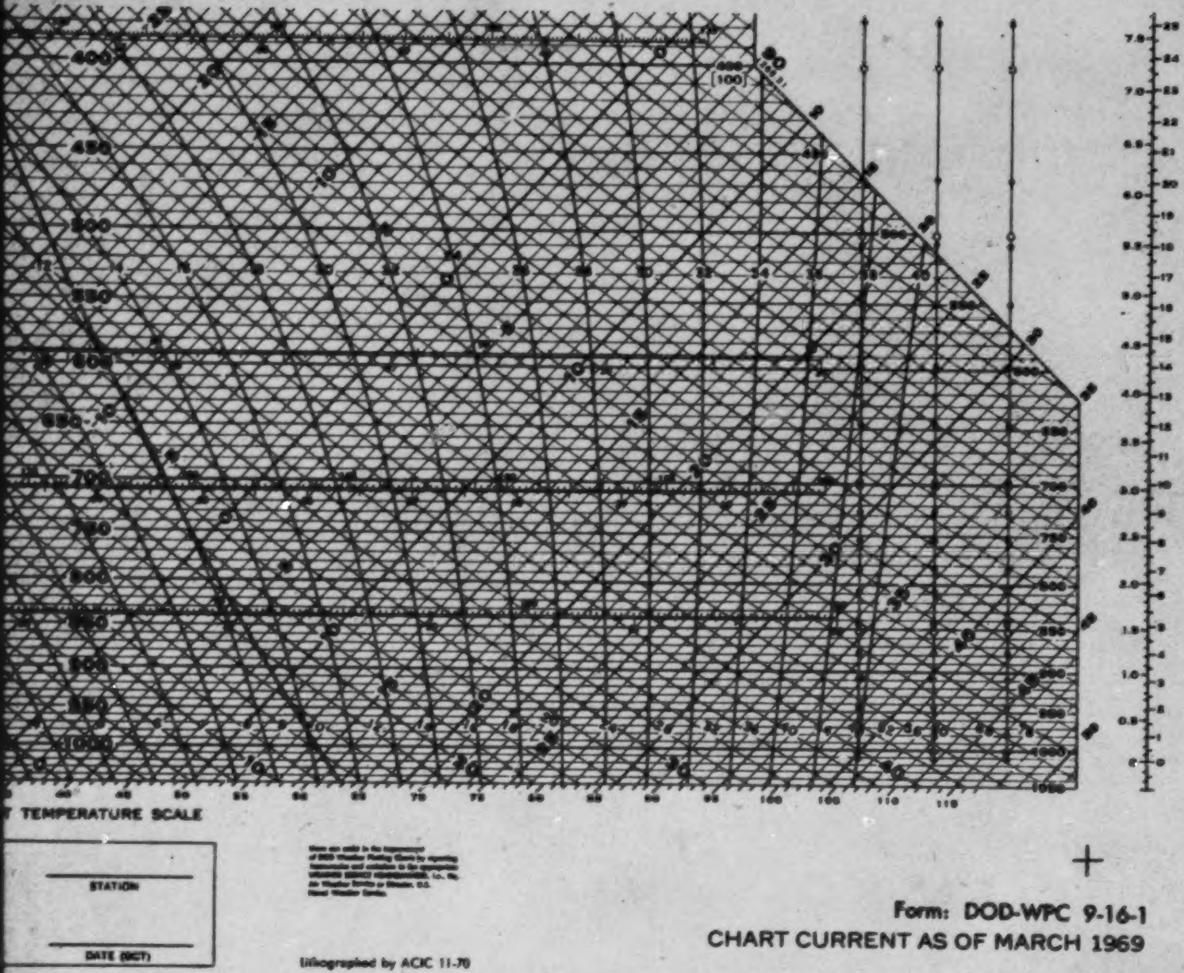
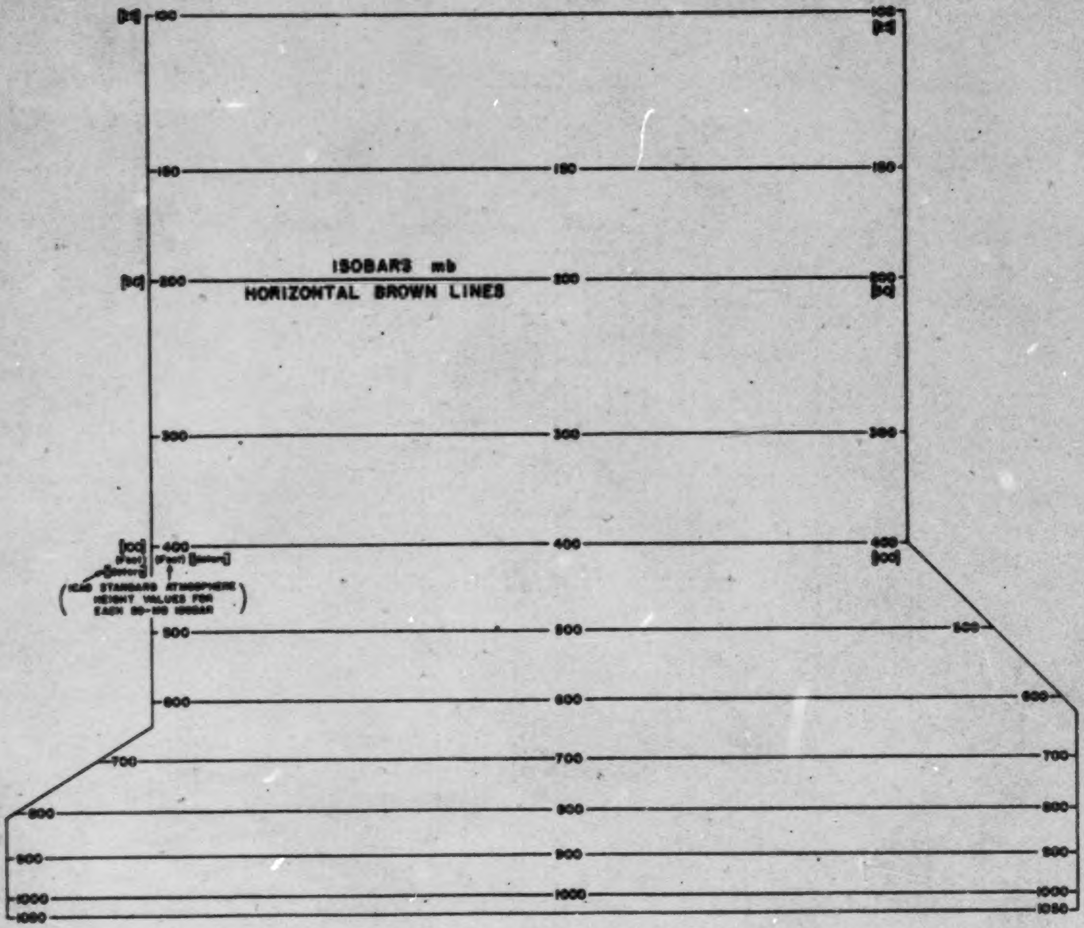


Figure 11-29.—A portion of a small scale SKEW-T Log P Diagram.

209.407


100
150
ISOBARS mb
HORIZONTAL BROWN LINES
200
300
400
ICAO STANDARD ATMOSPHERE
HEIGHT VALUES FOR
EACH 50-100 ISOBAR
500
600
700
800
900
1000
1050

209.408

Figure 11-30.—Example of isobars on the SKEW-T Diagram.

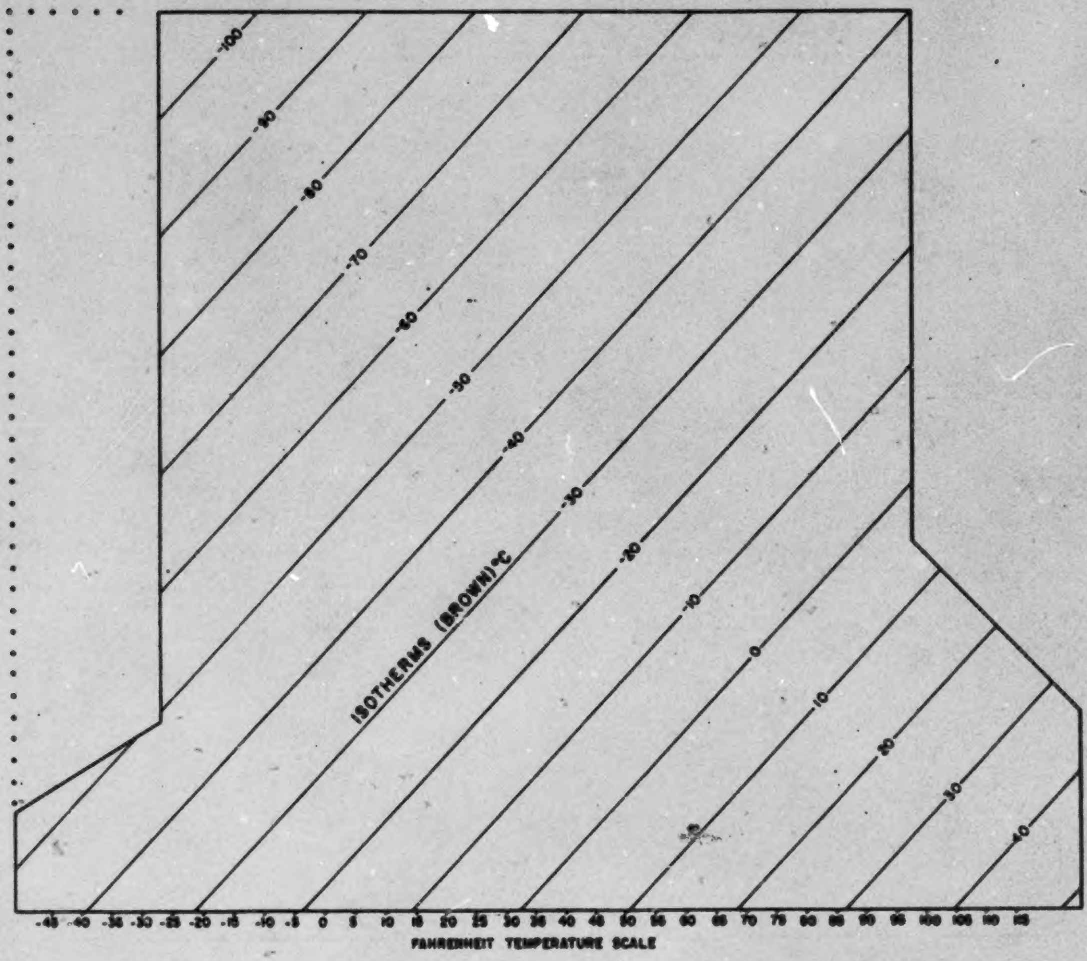
to the upper left. They indicate the rate of temperature change in a parcel of air rising or descending adiabatically. They are labeled for each multiple of 10° C. (See figure 11-32.)

4. SATURATION ADIABATS—These are the slightly curved, solid green lines, sloping from the lower right to the upper left. Each is labeled with the Celsius temperature value of its point of intersection with the 1000-mb isobar. (See figure 11-33.)

5. SATURATION MIXING-RATIO LINES—The slightly curved, dashed green lines, sloping from the lower left to the upper right. Labeled in parts of water vapor per 1000 parts of dry air (grams/kilogram). (See figure 11-34.)

Other data are printed on the diagram including contrail-formation curves to aid in forecasting contrails.

The diagram is printed by the Defense Mapping Agency Aerospace Center (DMAAC) and can be requisitioned by Naval Activities in accordance with instruction in the DOD Catalog of Weather Plotting Charts NAVAIR 50-1G-524.


-100
-90
-80
-70
-60
-50
-40
-30
-20
-10
0
10
20
30
40
ISOTHERMS (BROWN) °C
-45 -40 -35 -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115
FAHRENHEIT TEMPERATURE SCALE

209.409

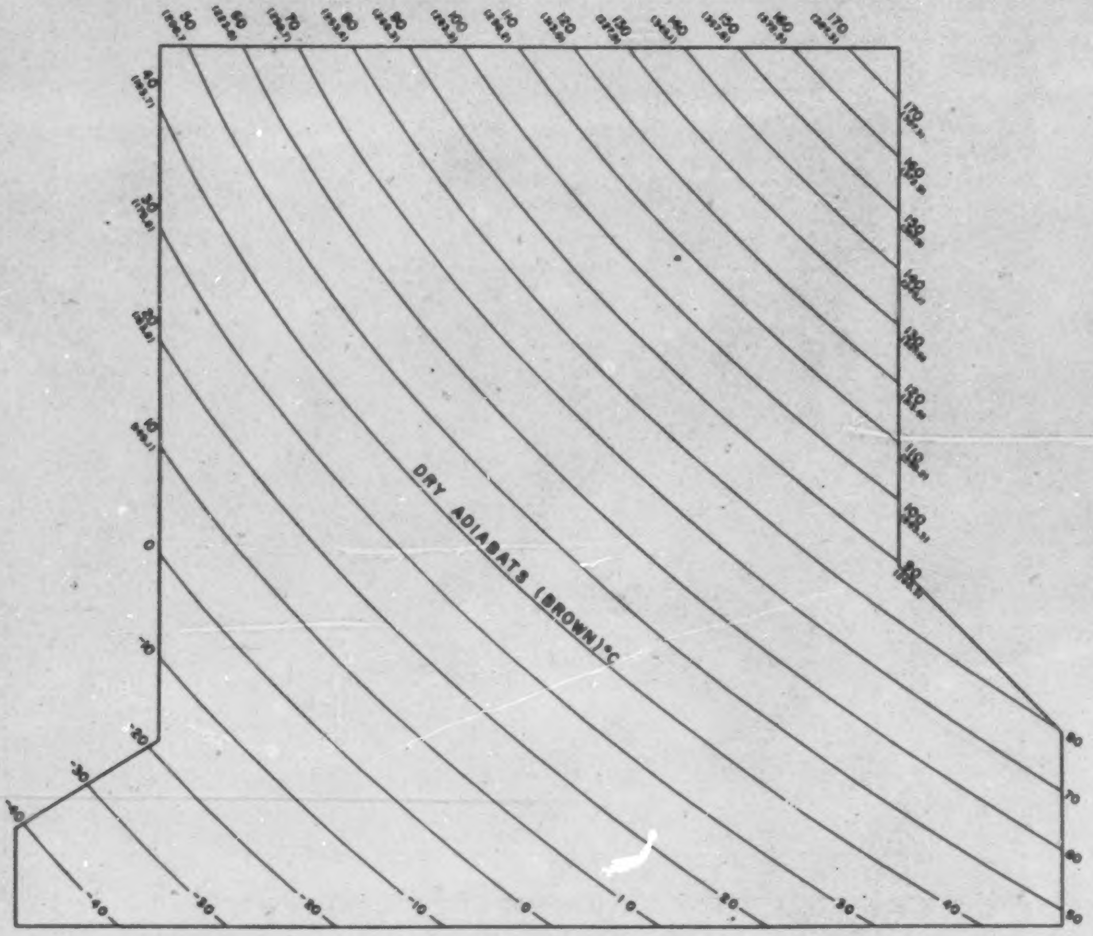
Figure 11-31.—Example of isotherms on the SKEW-T Diagram.

PLOTTING THE DIAGRAM

At some stations the first step in plotting is to trace the data from the previous sounding onto the new chart for continuity. This is accomplished by tracing the temperature and dew-point temperature curves only, in black pencil or ink, without transcription of data or circling of any points. Next obtain the upper air data for the station in question, which will generally be received over the teletype and in code form. After decoding this message (discussed in the previous chapter) the plotting procedures to be followed are as follows:

1. LEGEND BLOCK-Fill in station number, station identification, time, date (including month and year), and plotter's last name, initials, and rate.

2. TEMPERATURE CURVE-For each mandatory and significant level the temperature will be plotted to the nearest one-tenth degree, with


50
60
70
80
90
100
110
120
130
140
150
160
170
40
30
20
10
0
-10
-20
-30
-40
170
160
150
140
130
120
110
100
90
80
70
60
50
-40
-30
-20
-10
0
10
20
30
40
DRY ADIABATS (BROWN)°C

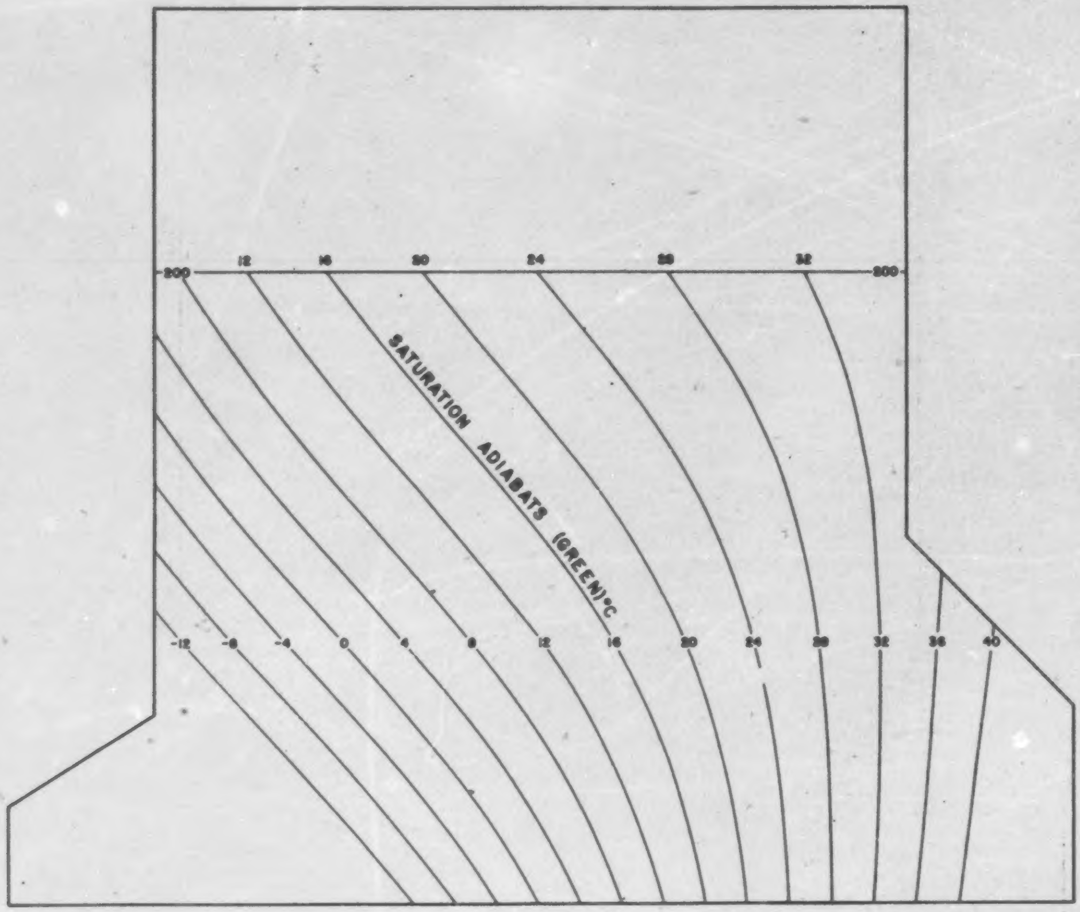
209.410

Figure 11-32.—Example of dry adiabats on the SKEW-T Diagram.

a one-eighth-inch circle drawn around each plot (⊙). After plotting all levels connect each plot with a solid blue line.

3. DEW-POINT TEMPERATURE CURVE-Subtract the dew-point depression from the temperature for each level and plot as described for the temperature curve. These points are connected by a dashed blue line. To assist in plotting the dew-point curve and to conserve time, a dew-point depression plotting scale (DOD WPC 9-16-5) has been devised. It is a clear plastic strip with numbers printed on both edges and imprinted in increments equal to one degree (1°) of temperature. These increments enable you to plot the dew-point depression directly from the report without a mathematical conversion.

4. PRESSURE ALTITUDE CURVE-To accomplish this a modification to the chart must be made. Starting with the 40-degree isotherm on the right hand side of the chart, label it O meters and for every succeding 10-degree

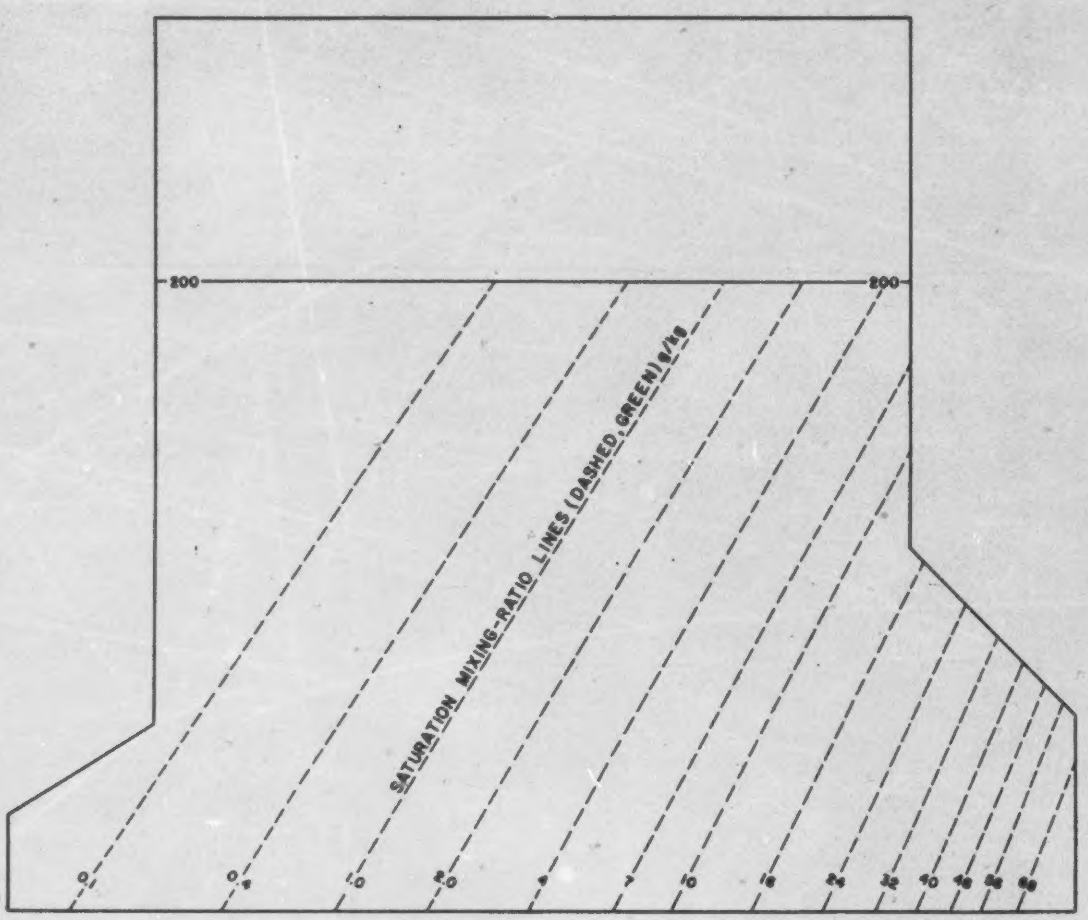


209.411

Figure 11-33.—Example of saturation adiabats on the SKEW-T Diagram.

isotherm, label in 1500-meter increments (i.e. 30° = 1500, 20° = 3000, 10° = 4500, etc.). Next, for each mandatory level enter the height value from the code on its respective level and to the right-hand side of the chart. Now plot each height and enclose it in a one-eighth inch box (□), remembering that every isotherm-isoheight line equals 150 meters. (Note: In many cases you will have to interpolate between two isotherm-isoheight lines to arrive at the reported height.) Finally, connect all the plots with a solid blue line. The completed line should curve slightly to the right with height. (See figure 11-35.)

5. WIND DATA-Plot wind data as received in the rawinsonde report on the open circles of the wind staffs in the same color as the corresponding sounding curves, using the methods described in the plotting section of this chapter. Wind data at other levels, taken from the winds-aloft report for the same time, may be plotted on the solid dots if required.



209.412

Figure 11-34.—Example of saturation mixing-ratio lines on the SKEW-T Diagram.

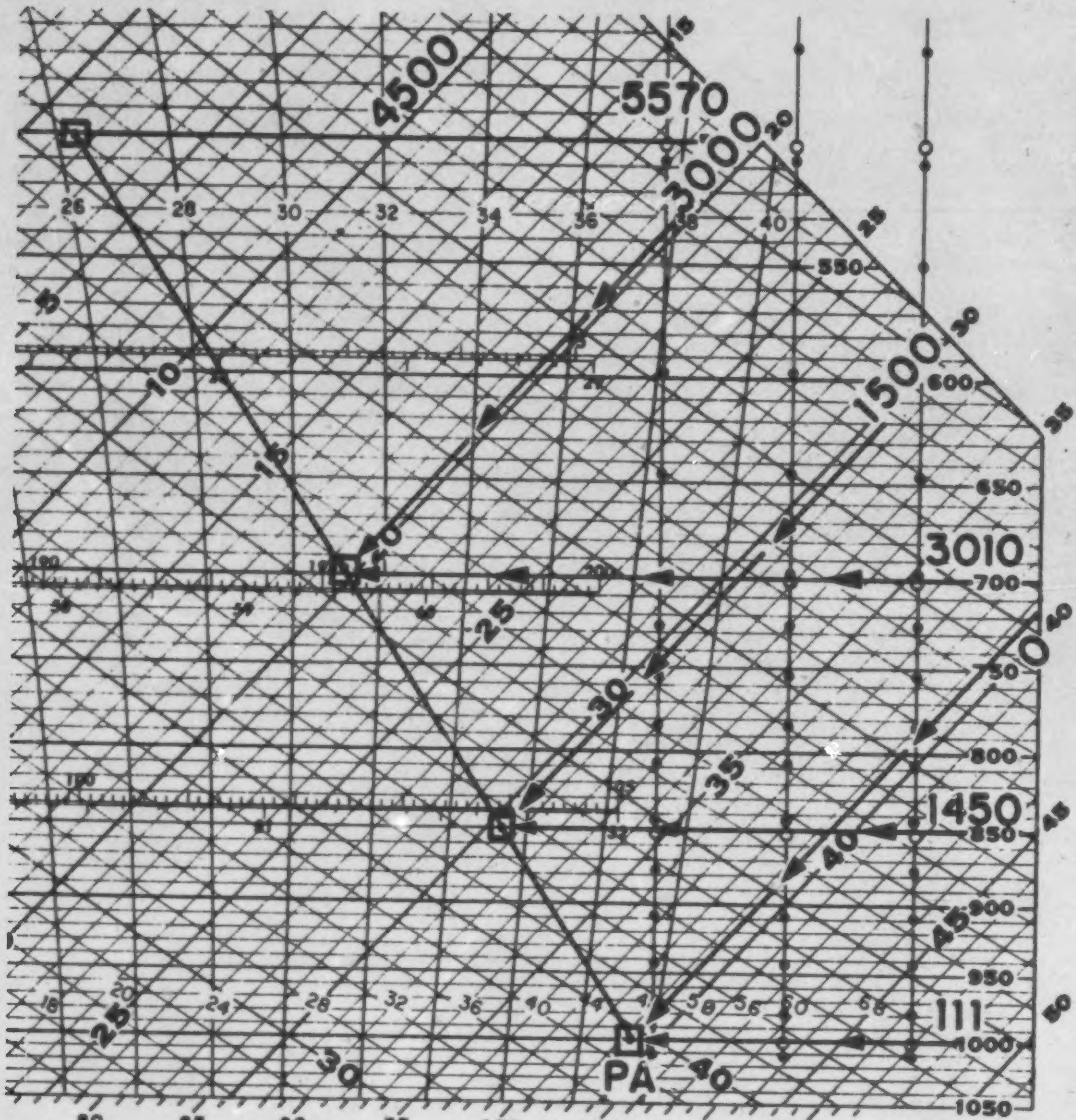
6. OTHER DATA-Miscellaneous data, such as layer thickness curve and tropopause data, as prescribed by local command or the forecaster, may also be plotted on the chart.

COMPUTATIONS ON THE DIAGRAM

Computations on the SKEW-T Diagram that you make will serve as the primary tools used by the forecaster in preparing the daily forecast. It can be used to analyze an air mass or a front, and it may also be used to forecast maximum and minimum temperatures, thunderstorms, fog, icing, and a host of other parameters.

Some of the parameters that can be determined by using the SKEW-T Diagram and the procedures for computing them are as follows:

1. LIFTING CONDENSATION LEVEL (LCL)-This is the height at which a parcel of air


4500
5570
3000
1500
3010
1450
111
PA
26
28
30
32
34
36
38
40
15
20
25
30
35
40
45
50
5
10
15
20
25
30
35
40
45
550
600
650
700
750
800
850
900
950
1000
1050
18
20
24
28
32
36
40
44
48
52
56
60
68
25
30
40
80
85
90
95
100
105
110
115

209.413

Figure 11-35.—Example of plotting the pressure altitude curve on the SKEW-T Diagram.

becomes saturated when it is lifted dry adiabatically. To obtain, find the intersection of the saturation mixing-ratio line of the surface dewpoint and the dry adiabat of the surface temperature. (See figure 11-36.)

2. CONVECTION CONDENSATION LEVEL (CCL)-This is the height at which a parcel of air, if heated sufficiently from below, will rise adiabatically until it is just saturated. To obtain, proceed upward along the saturation mixing-ratio line of the surface dewpoint until you intersect the temperature curve of the sounding. This is the CCL. (See figure 11-35.)

3. CONVECTION TEMPERATURE (CT)-This is the surface temperature that must be attained, if convective clouds are to form by solar heating of the surface-air layer. To obtain, proceed from the CCL dry adiabatically to the surface level and read the temperature at this point. (See figure 11-35.)

4. LEVEL OF FREE CONVECTION (LFC)-The level at which a parcel of saturated air becomes warmer than the surrounding air and begins to rise freely. To determine, start at the LCL and draw a line upward, parallel to the nearest saturation adiabat until you intersect the temperature curve; this is the LFC. All soundings, however, do not have a LFC.

5. POSITIVE AND NEGATIVE AREAS-When a parcel on a sounding lies in a stable layer, energy has to be supplied to it, if it is to move either up or down. This is called a negative area. A positive area is when a parcel can move freely because it is in a layer where the adiabat it follows is warmer than the surrounding environment.

To determine the positive/negative areas for convective lifting, construct a saturation adiabat from the CCL to the top of the chart and a dry adiabat downward to the surface from the CCL. Any area bounded by the temperature curve on the left and the drawn saturation adiabat on the right is positive and shaded red. Any area bounded by the temperature curve on the right and the drawn saturation adiabat on the left is negative and shaded blue. (See figure 11-37.)

To determine the positive/negative areas for mechanical lifting, continue the saturation adiabat from the LFC (which was previously determined) to the top of the chart. Below the LFC the area bounded on the right by the temperature curve and on the left by the dry adiabat, to the LCL, then bounded by the saturation adiabat to the LFC again, is a negative area and shaded blue. Above the LFC, any area bounded by the temperature curve on the left and the saturation adiabat on the right is positive and shaded red, while areas bounded by the temperature curve on the right and the saturation adiabat to the left are negative and shaded blue. (See figure 11-38.)

6. STABILITY INDEX (SI)-This is a computed value used to forecast the probability of thunderstorm and tornado occurrence. Values greater than +3 indicate that shower activity is unlikely. Values +3 to -2 indicate shower and thunderstorm activity are likely, while values of -3 or less are associated with severe thunderstorm activity, and a value of below -6 indicates the possibility of tornadoes.

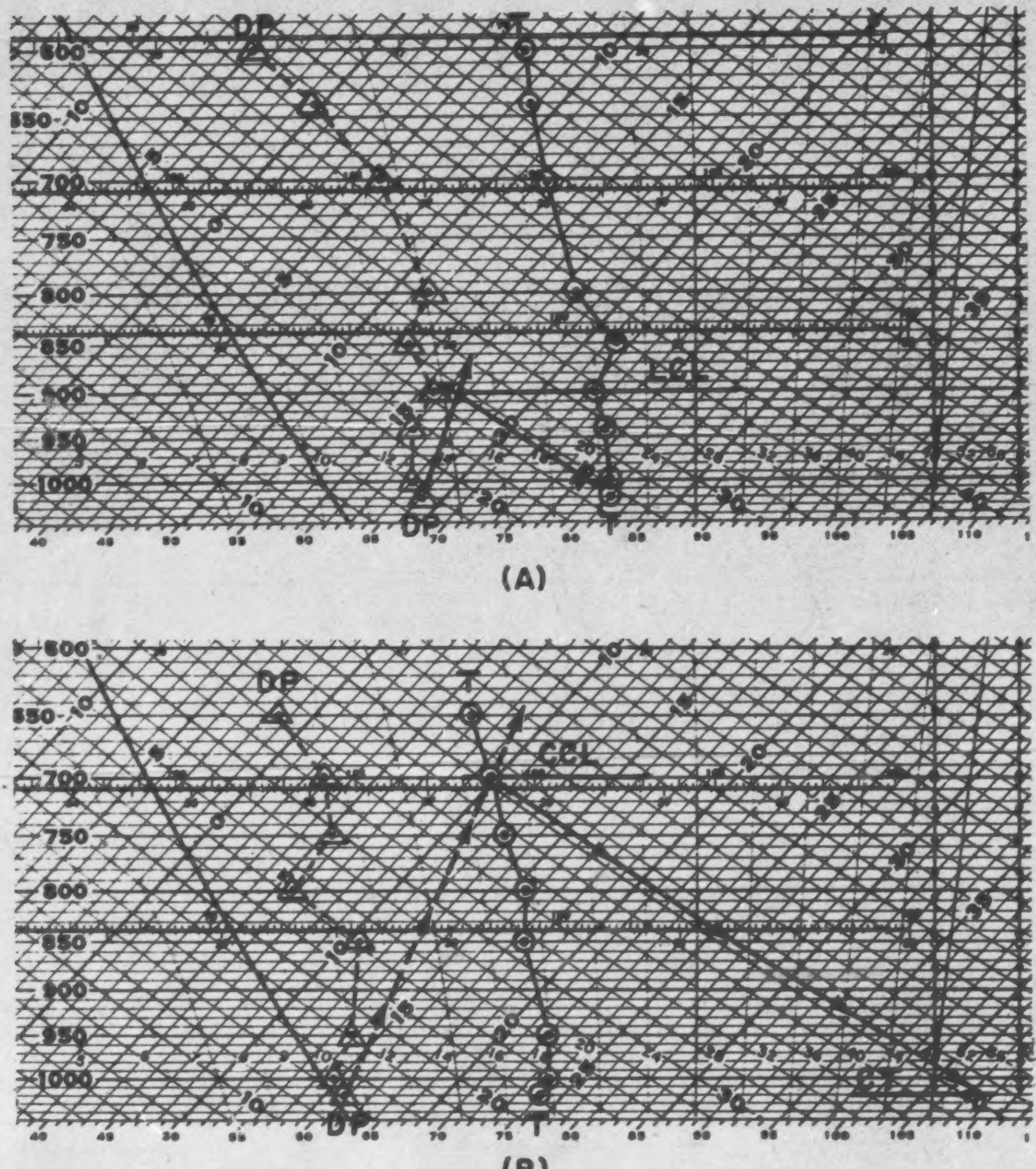
Although several methods are available to compute this value, only one method will be discussed here. This is the SHOWALTER METHOD. In this method, determine the LCL for the 850-mb level; from the 850-mb LCL, draw a line upward parallel to the nearest saturation adiabat until it intersects the 500-mb level. Read the temperature (T') at this point, then read the actual temperature (T_{500}) of the 500-mb level. Now algebraically subtract (T') from (T_{500}); the value of the remainder, including its algebraic sign, is the value of the SI. (See figure 11-39.)

There are many more parameters that can be determined on the SKEW-T Diagram.

To aid in determining parameters and for a more detailed description of procedures used to determine the parameters already discussed, the Aerographer's Mate should refer to NA50-1P-5, Use of the SKEW-T Diagram in Analysis and Forecasting; NA50-1P-6, Forecasting of Aircraft Condensation Trails; NA50-1P-7, Computation of Atmospheric Refractivity on the USAF SKEW-T Diagram; and NA50-1P-8, Memorandum of Density-Altitude.

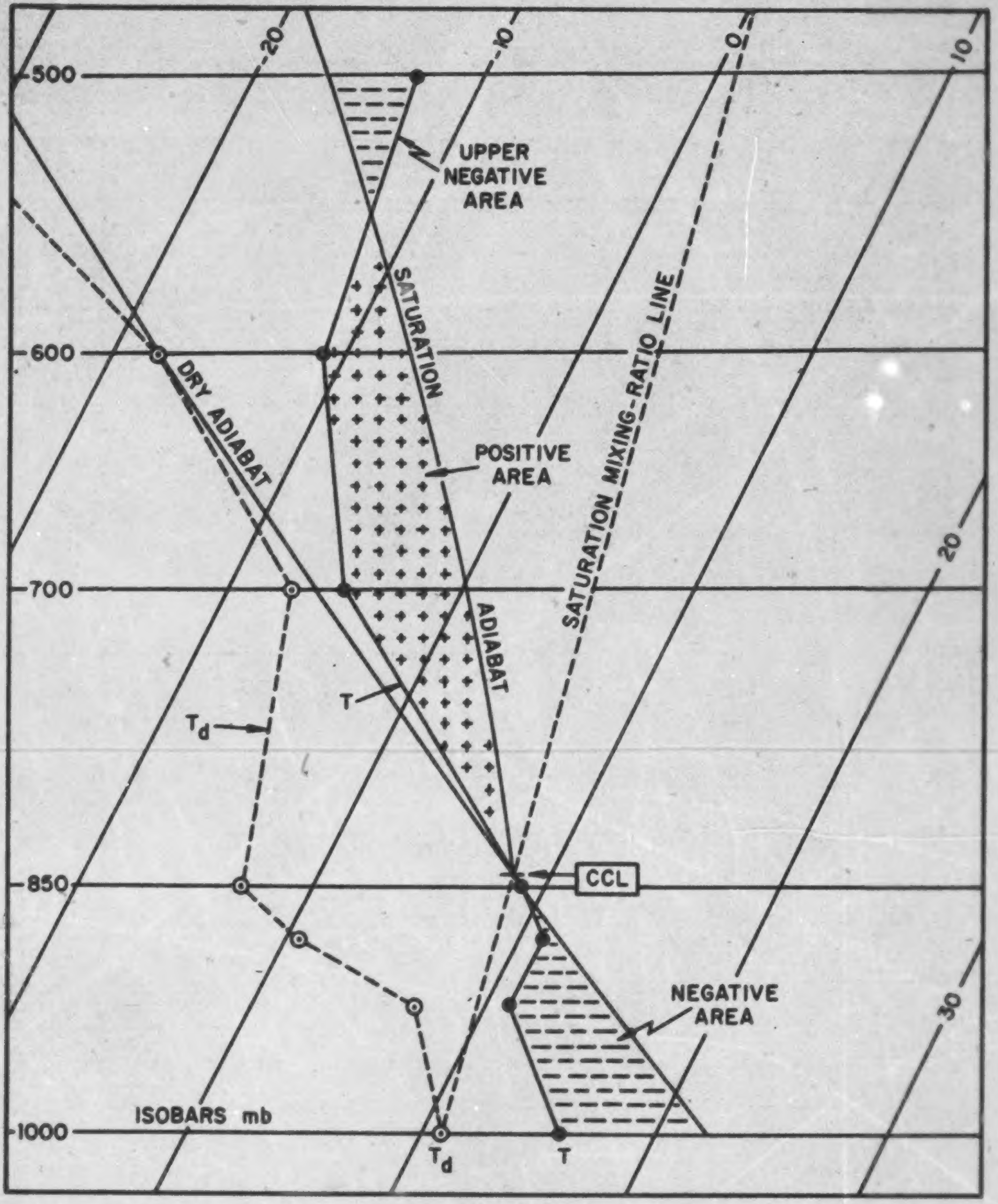
FILING AND DISPLAY

An extensive amount of weather data is constantly received in most weather offices via teletypes, facsimile, satellite and other means. This data must be sorted, identified, and displayed properly, so that is available



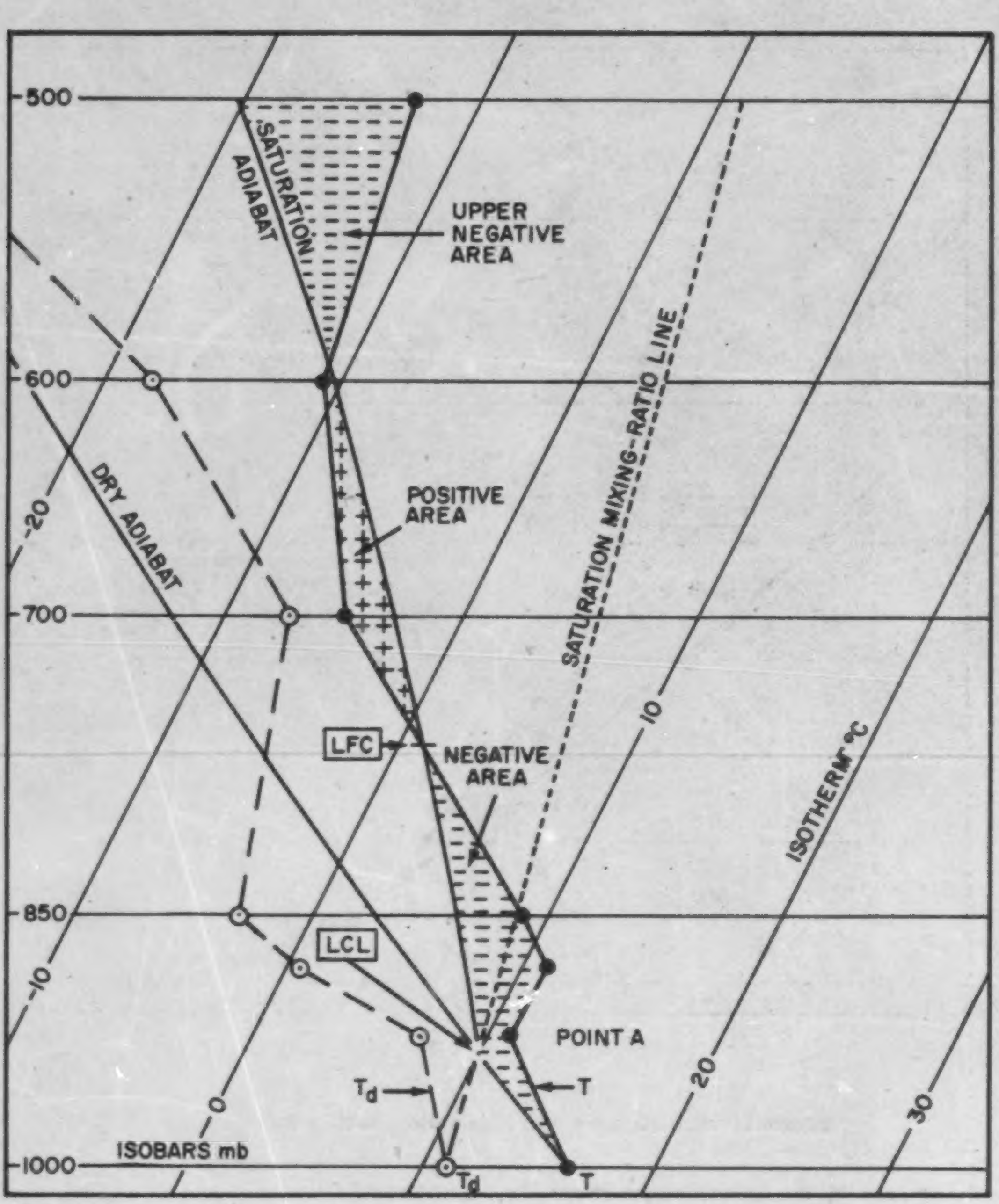
209.414

Figure 11-36.—Determining (A) lifting condensation level LCL, (B) convective condensation level CCL and convection temperature CT, on the SKEW-T Diagram.


20
10
0
10
20
30
500
600
700
850
1000
UPPER
NEGATIVE
AREA
SATURATION
ADIABAT
POSITIVE
AREA
SATURATION MIXING-RATIO LINE
DRY ADIABAT
T
T_d
CCL
NEGATIVE
AREA
ISOBARS mb
T_d
T

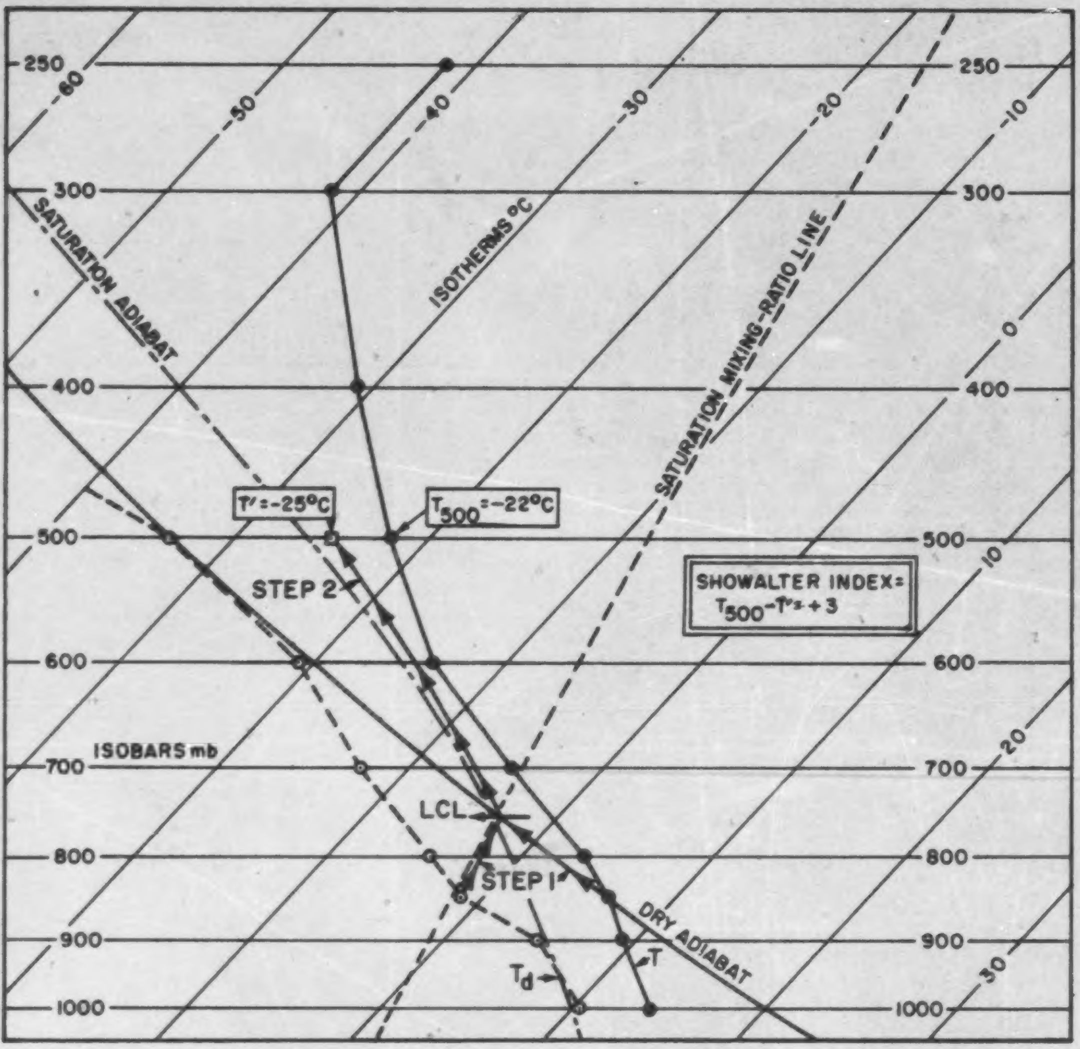
209.415

Figure 11-37.—Determination of the positive and negative energy areas on a sounding due to convective lifting.


500
600
700
850
1000
SATURATION ADIABAT
UPPER NEGATIVE AREA
POSITIVE AREA
DRY ADIABAT
-20
LFC
NEGATIVE AREA
SATURATION MIXING-RATIO LINE
10
ISOTHERM °C
LCL
-10
POINT A
Td
T
20
30
0
ISOBARS mb
Td
T

209.416

Figure 11-38.—Determination of the positive and negative energy areas on a sounding due to mechanical lifting.



209.417

Figure 11-39.—Example of the Showalter Stability Index method.

for ready use by all authorized personnel. To accomplish this the Aerographer's Mate must be able to interpret the identifiers of each message or product. The following sections will introduce the various types of data, methods of identifying them, and the disposal methods.

TELETYPE DATA

As an observer, you will be required to perform a number of tasks using a wide range of weather messages received on the teletype circuits. Some of these tasks include sorting weather messages, filing, plotting weather charts, preparing local weather messages for transmission, or relaying information from the teletype messages to the forecaster and pilots.

Identifiers

The first line of all weather messages contains the heading (e.g., SACA MKPB 041500) which generally includes the type of data (SA-Aviation Hourlies), the geographical location (CA-Caribbean), originator of the message (MKPB-Barbados), the date (04-4th day of the month), and time of the message (1500-in GMT).

Sometimes the message heading may include a one- or two-digit number between the geographical location and originator (e.g., ABUS 5 KWBC 061000 or SMUS 72 KWBC 101400). A single digit differentiates between two or more bulletins of similar contents from the same geographic area, while two digits usually indicate the WMO (World Meteorological Organization) block number of stations contained in a weather bulletin.

There is an extensive number of data and geographical designators used in weather message headings and you are not expected to memorize them all. Familiarization with many of them will occur once you start working in the weather office. Included in appendix IX of this manual is a listing of some examples used in weather message headings. For a complete listing refer to AWSM 105-2 Vol. 1 or International Weather Schedules Service "O" 7330.6.

FACSIMILE DATA

Most Naval Weather Service offices display the current weather charts, plus those for the past 24 hours or longer (depending on office routine). This display is designed to afford maximum usage to the forecaster, as well as a ready reference for pilots and other authorized personnel. However, before this can be accomplished, the observer must be able to readily identify the various charts.

All facsimile products will have a data block affixed to them; figure 11-40 is an example of the data block. This data block identifies the chart as to the type, geographical location, originator, date, and time. Although these data usually are found in the lower left-hand corner of the chart, they may appear anywhere.

```
NATIONAL WEATHER SERVICE
2100Z TUE JUL 24 1973
N120.  NMC SFC ANALYSIS
ASUS                N120.
```

209.418

Figure 11-40.—Example of a facsimile chart data block.

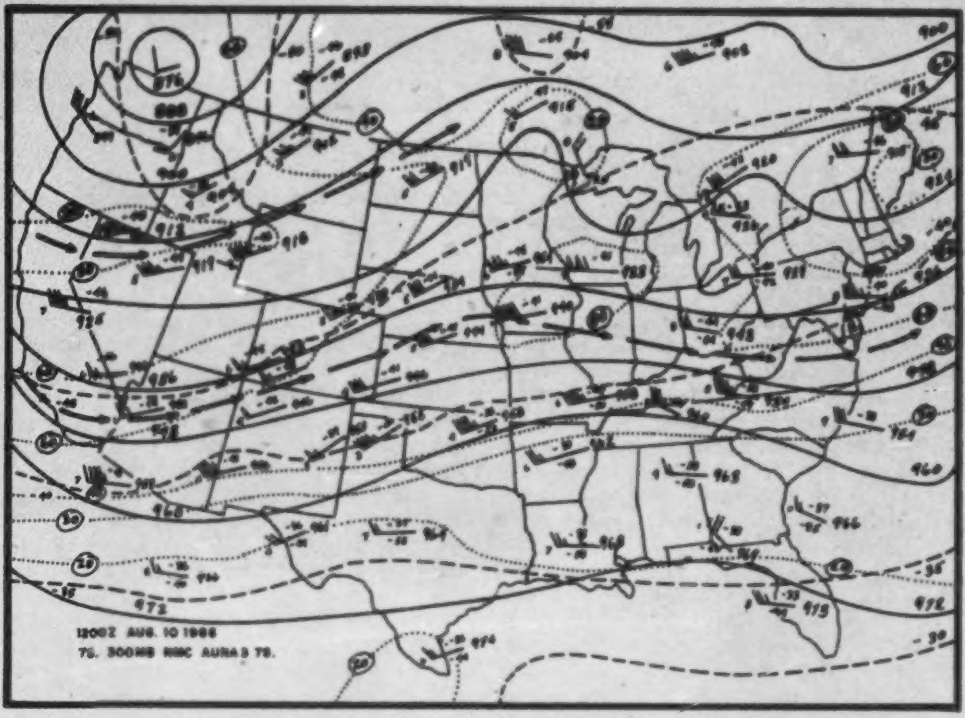
Using the same publication referred to in the previous section on teletype data, the type and geographical location can be determined.

Figures 11-41, 11-42, and 11-43, show some examples of facsimile charts; however, there are many other charts showing other data and other areas. These can easily be identified if you can read the data block. In fact, after working with these charts a short time you will be able to identify them simply by noting the type of data that is on them.

A vast number of weather charts are available through the National Meteorological Facsimile (NAMFAX) Circuits for stations in the United States, and through the Fleet Facsimile Broadcast for ships and overseas stations. A few of the varied weather charts prepared for facsimile transmission are as follows:

1. Prognostic (prog) charts are simply the basic charts projected into the future. Among the many prog charts, the most commonly used and the most important ones are the surface prog charts, the constant pressure prog charts, sea condition prog charts, severe weather outlook charts, significant weather (high-level prognoses, and the 5-day prog charts.)

2. Weather depiction charts are regularly transmitted over the facsimile network. They are charts which outline areas of significant weather. The entries on this chart include sky cover, ceiling or height of lowest scattered clouds at stations reporting only scattered clouds, visibility 6 miles or less, and any weather the stations are experiencing. Areas with ceilings below 1,000 feet or visibilities below 3 miles, or both, are outlined, and areas with ceilings 1,000 to 5,000 feet inclusive and visibilities 3 miles or greater are scalloped outlined. For



209.419

Figure 11-41.—Example of an Upper Air Analysis facsimile chart.

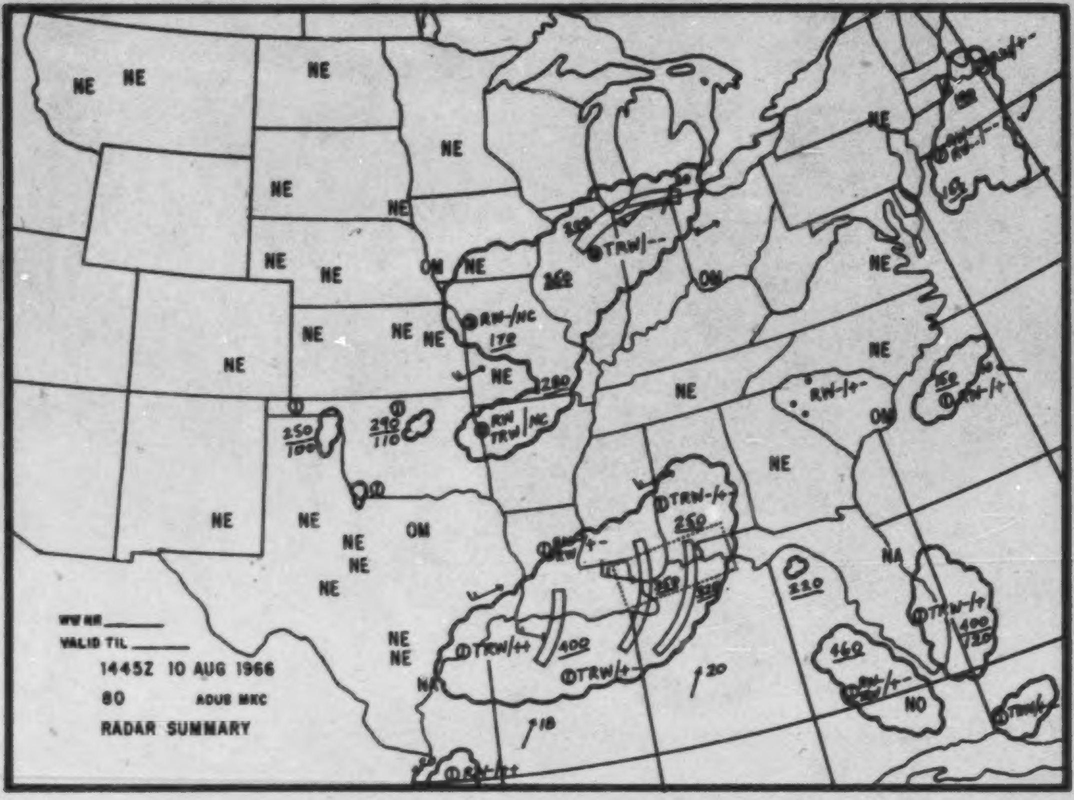
display purposes, naval weather units normally shade the plain outlined areas in red and the scalloped outlined areas in blue.

3. Radar summary charts show the distribution of the echoes reported on hourly radar reports. These charts indicate the location, coverage, tops, and movement of the echoes.

4. Charts are received containing tropopause heights, temperatures, and wind direction and velocity for selected stations in the United States.

5. An increasingly large number of the weather charts currently in use by the Naval Weather Service are prepared by numerical methods, using electronic digital computers (EDC). Some of these computers and their principles of operation were mentioned briefly in chapter 9 of this manual. The Naval Environmental Data Network (NEDN) and the facsimile network used in the dissemination of these numerical products are discussed in chapter 7 of this manual. The NEDN is used to distribute the numerical products originating at Fleet Numerical Weather Central, Monterey, California, and the (NAMFAX) is used for numerical products originating at the National Meteorological Center (NMC), Suitland, Maryland.

6. Other charts used by Naval Weather Service units include the freezing level chart, which indicates the height of the



209.420

Figure 11-42.—Example of a Radar Summary facsimile chart.

freezing level; the precipitable water analysis, which indicates the moisture content from the surface up to 500 millibars; the stability index chart, which outlines areas of stability and instability; the rainfall and snow cover charts; the maximum and minimum temperature charts; and many others.

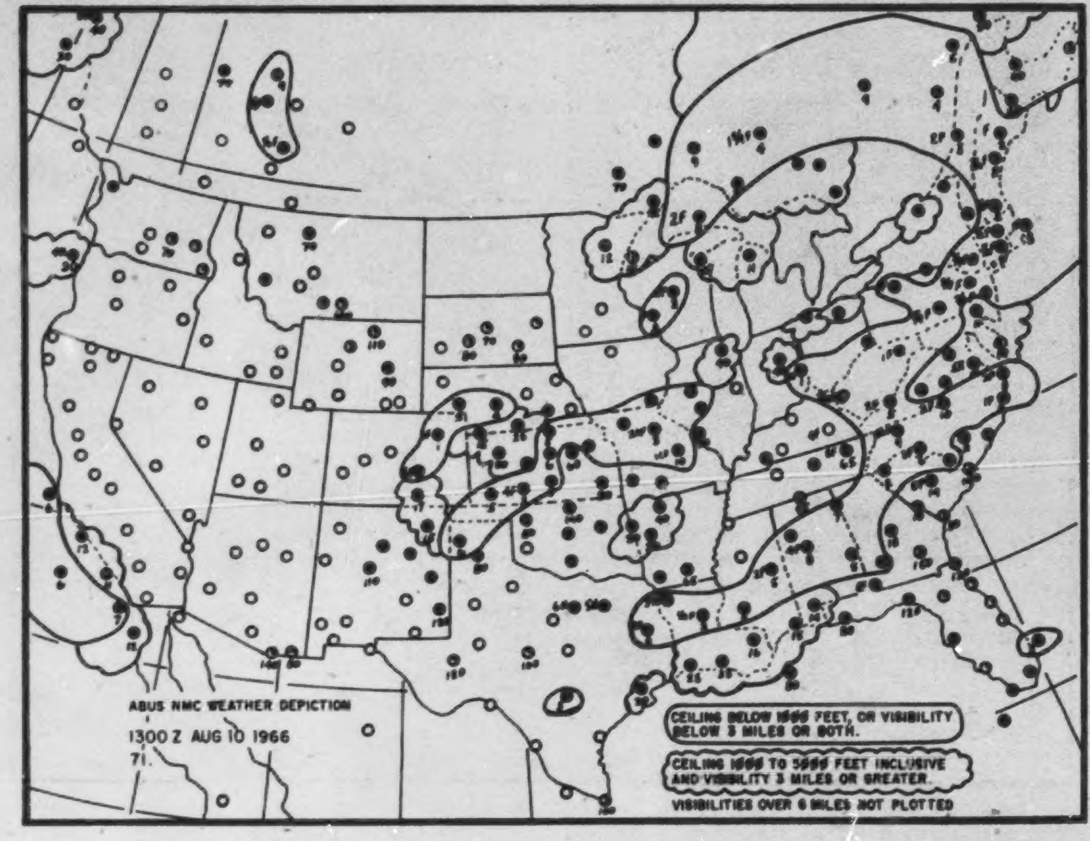
As advances continue in the field of meteorology, new charts will continue to be added and some of the older ones deemphasized. However, the Aerographer's Mate will be required to keep abreast of these changes as they occur if he is to perform his duties to the best of his abilities.

SATELLITE DATA

Satellite data are received either directly from the satellite or over the facsimile network. If received via the facsimile network, all that is required, is to read the data block to identify its content. Data received directly are identified as to date, time, and location by the operator of the tracking equipment. The display and filing of this data will be in accordance with local directives.

WEATHER WARNINGS

Warnings consist of many different types, and the local procedures for display and filing


ABUS NMC WEATHER DEPICTION
1300 Z AUG 10 1966
71.
CEILING BELOW 1000 FEET, OR VISIBILITY BELOW 3 MILES OR BOTH.
CEILING 1000 TO 5000 FEET INCLUSIVE AND VISIBILITY 3 MILES OR GREATER.
VISIBILITIES OVER 6 MILES NOT PLOTTED

209.421

Figure 11-43.—Example of a Weather Depiction facsimile chart.

them may differ. The following procedures, however, are most common:

1. Wind Warnings, High Sea Warnings, and Small Craft Warnings received via teletype or the communications center are brought to the attention of the forecaster, then filed on a clipboard accessible to those concerned. If aboard ship or at an island station, the warning is usually plotted on a display map.

2. Local Severe Weather Warnings (WW) are brought to the forecaster's attention immediately, then plotted on a display map in the flight briefing area and filed on the Severe Weather Warning clipboard.

3. Hurricane Warnings (WH) are brought to the attention of forecasters and all other key personnel, then plotted on one or two display maps and filed in the history folder. One of the plotted maps is used by the forecaster for briefing purposes, and the other is generally displayed in the briefing area for dissemination to all other concerned personnel.

OTHER DATA

These data include such items as the daily forecast, radioactive fallout plots, SKEW-T Diagrams, and the local observation. Procedures for display and filing vary considerably with

Table 11-4.—Guide lines for disposal of Naval Weather Service records

	FWC/FNWC	FWF	NWSED	OT
Locally plotted and analyzed for surface and upper-air (mandatory levels) charts for 00, 06, 12, and 1800Z.	Retain charts for two years; then forward to NWSED, Asheville for microfilming.	Retain for 8 years (Destroy)	Retain for 1 year (Destroy)	Retain locally (Destro
Locally prepared (for transmission), facsimile, NEDN and APT charts.	Retain for 3 months (Destroy)	Retain for 3 months (Destroy)	NA	N
Received info: facsimile, NEDN, APT, teletype data, etc.	Destroy when no longer required locally	Destroy when no longer required locally	Destroy when no longer required locally	Destroy no long quired
Locally prepared computer charts for 00, 06, 12, and 1800Z.	Retain data and Program permanently	NA	NA	N
Locally prepared oceanographic data charts.	Retain for 1 year unless otherwise directed	NA	NA	N

Table 11-4.—Guide lines for disposal of Naval Weather Service records

	FWC/FNWC	FWF	NWSED	OTHER
nd analyzed pper-air) charts for 800Z. .	Retain charts for two years; then forward to NWSED, Asheville for microfilming.	Retain for 8 years (Destroy)	Retain for 1 year (Destroy)	Retain as required locally (Destroy)
(for trans- le, NEDN and	Retain for 3 months (Destroy)	Retain for 3 months (Destroy)	NA	NA
acsimile, pe data,	Destroy when no longer required locally	Destroy when no longer required locally	Destroy when no longer required locally	Destroy when no longer required locally
computer , 12, and	Retain data and Program permanently	NA	NA	NA
oceano- ts.	Retain for 1 year unless otherwise directed	NA	NA	NA

each unit and will be governed by local instructions.

DISPOSAL

Naval Weather Service activities will follow the disposal guide lines outlined in NAVWEASERVCOMINST 5212.1 ( ) for weather records. A brief summary of these disposal guidelines is given in table 11-4. Classified data are disposed of in accordance with OPNAVINST 5510.1 ( ), as applicable, with a view towards declassification when possible.

CHAPTER 12

THE GOVERNING FUNDAMENTALS OF METEOROLOGY

The treatment of meteorology in this manual progresses from the overall governing fundamentals of meteorology in this chapter, to a thorough description of the atmospheric circulation, air masses and fronts, meteorological elements, and fundamentals of oceanography in chapters 13 through 16.

As unpredictable as the weather seems, it is still the result of a great number of factors which operate according to well-defined laws. If this were not true, it would be impossible to forecast with even a small amount of accuracy.

Physics is devoted to finding and defining problems as well as to reaching their solutions. Physics not only teaches a person to be curious about the physical world around him but also gives him a means of satisfying his curiosity. Physics is the basic science that deals with motion, force, and energy as shown in the laws of mechanics, electricity, magnetism, sound, heat, and light.

Your understanding of the weather elements and your ability to analyze meteorological situations depend upon your knowledge of the application of some of the fundamental principles of physics. This does not mean that you must be able to understand all of the complicated theories of meteorology; it does mean, however, that you should have a fair working knowledge of some of the more elementary aspects of physics, as applied to the atmosphere as well as other physical laws, in order to perform your duties as an Aerographer's Mate in a creditable manner.

In order to accomplish this, an understanding of mathematics will become important to an ever increasing degree as you progress in your studies of meteorology.

The apprentice Aerographer's Mate requires a basic knowledge of ratio, proportion, interpolation, percentage, and trigonometric functions of a right triangle. As you move further into the field of meteorology, you will find it helpful to increase your knowledge in this area by referring to the training manuals entitled: Mathematics, Vol. 1, NAVEDTRA 10069-C, Mathematics, Vol. 2, NAVEDTRA 10071-B, or Mathematics, Vol. 3, NAVEDTRA 10073-A. Not to be overlooked as additional sources of information are the many mathematic courses offered by colleges. Information on these courses and manuals may be obtained from your Educational Service Office.

DEFINITION OF METEOROLOGY

Meteorology is defined as the study of phenomena of the atmosphere. This includes not only the physics, chemistry, and dynamics of the atmosphere, but is extended to include many of the direct effects of the atmosphere upon the earth's surface, the oceans, and life in general. The goals often ascribed to meteorology are the complete understanding, accurate prediction, and artificial control of atmospheric phenomena.

Meteorology may be subdivided, according to the methods of approach and the applications to human activities, into a large number of specialized sciences. A few of the more common ones are applied meteorology, dynamic meteorology, synoptic meteorology, macro, meso, and micro meteorology.

EARTH-SUN RELATIONSHIP

Although the solar system has many components, we are primarily interested in only the earth and the sun. In this section the effect the sun has upon the earth is considered.

SUN

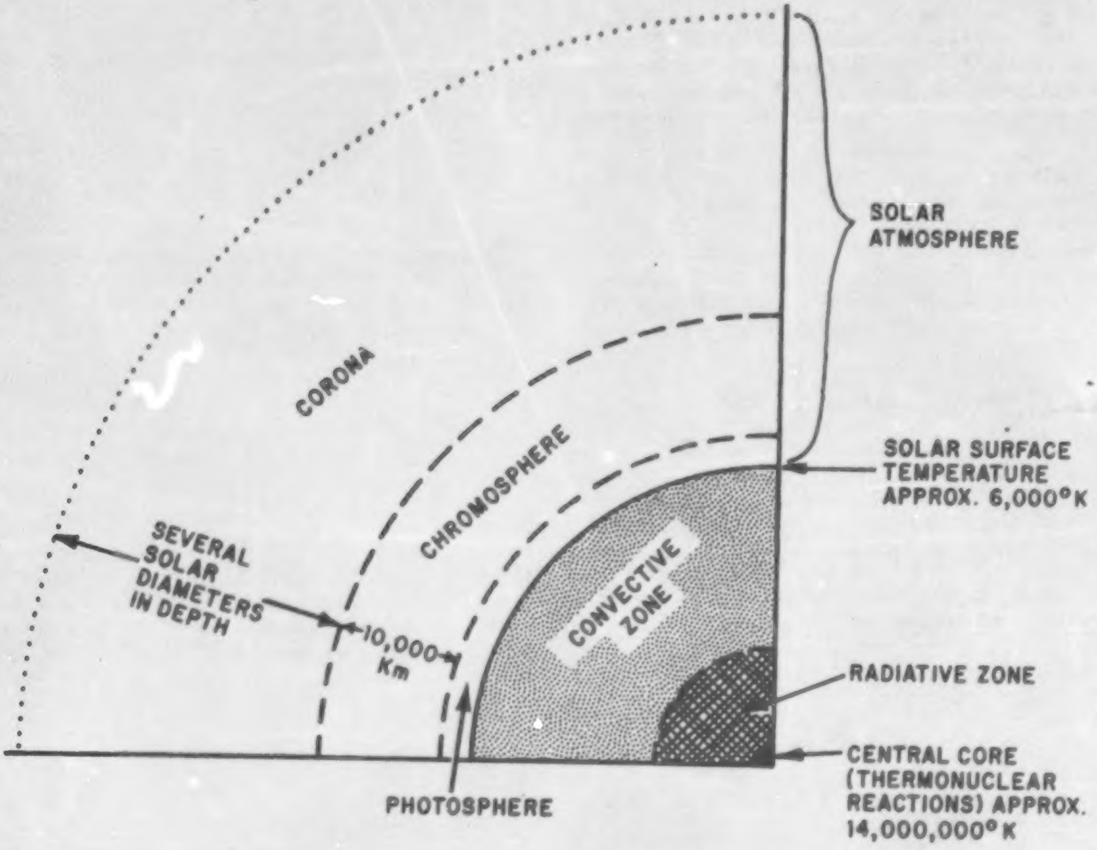
The sun may be regarded as the only source of heat energy that is supplied to the earth's surface and the atmosphere. All weather and motions in the atmosphere are due to the energy radiated from the sun.

The sun, with a surface temperature of about 6,000° K (10,300° F), radiates electromagnetic energy in all directions. The earth intercepts about one two-billionths of this energy. Most of the electromagnetic energy radiated by the sun is in the form of light waves. Only a tiny fraction is in the form of heat waves. Even so, better than 99.9 percent of the earth's heat is derived from the sun in the form of radiant energy.

Solar Composition

The sun may be described as a globe of gas heated to incandescence by thermonuclear reactions from within the central core. (See fig. 12-1.)

The tremendous heat (or energy) generated within the sun's core is transported by the radiative transfer of photons (a measurement of gamma radiation), which bounce from atom to atom, similar to bouncing balls, through the radiative zone. Within the convective zone, which extends very nearly to the sun's surface, the heated gases are raised buoyantly upwards with some cooling occurring and subsequent convective action until the gases are cooled to approximately 6,000° K (Kelvin or Absolute) at the sun's surface.


SOLAR ATMOSPHERE
CORONA
CHROMOSPHERE
SOLAR SURFACE TEMPERATURE APPROX. 6,000°K
SEVERAL SOLAR DIAMETERS IN DEPTH
10,000 Km
CONVECTIVE ZONE
RADIATIVE ZONE
CENTRAL CORE (THERMONUCLEAR REACTIONS) APPROX. 14,000,000°K
PHOTOSPHERE

210.29

Figure 12-1.—One-quarter cross/section depicting solar structure.

The main body of the sun, although composed of gases, is opaque and has a well-defined visible surface referred to as the photosphere. This is the source we see from which all light and heat of the sun is radiated. Above the photosphere is a more transparent gaseous layer referred to as the chromosphere with a thickness of about 10,000 km. Above the chromosphere is the corona, which may extend outward a distance of several solar diameters. As illustrated in figure 12-1, the photosphere, chromosphere, and the corona, comprise what may be referred to as the solar atmosphere.

Within the solar atmosphere certain more transient phenomena (referred to as solar activity) occur similar to the systems occuring within the earth's atmosphere. This activity consists of the phenomena in the following paragraphs which collectively describe the features of the solar disc.

Solar Prominences

Solar prominences are perhaps the most beautifully colored appendages of the sun. They appear as great clouds of gas, sometimes resting on the sun's surface and at other times floating free with no visible connection. When viewed against the solar disc, they appear as long dark filaments. They display a variety of shapes, sizes, and activity which defy general description.

The more active types appear hotter than the surrounding atmosphere with temperatures near 10,000,000° K.

Sunspots

Sunspots appear as relatively dark areas on the surface of the sun. They may appear singly or in more complicated groups dominated by large spots near the center.

Sunspots begin as small dark areas known as pores. These pores develop into full-fledged spots in a few days, with maximum development occurring in about 1 to 2 weeks. Decaying of the sunspots consists of the spot shrinking in size. This life cycle may consist of a few days for small spots to nearly 100 days for larger groups. The larger spots normally measure about 120,000 km. Sunspots appear to have cyclic variations in intensity, varying through a period of about 8 to 17 years.

Plages

Plages are large irregular bright patches which surround sunspot groups. They normally appear in conjunction with solar prominences or filaments and may be systematically arranged in radial or spiral patterns. Plages are features of the lower chromosphere and are often completely or partially obscured by an underlying sunspot.

Flares

Solar flares are perhaps the most spectacular of the eruptive features associated with solar activity. They appear as flecks of light which suddenly appear near activity centers, appearing instantaneously as though a switch were thrown. They rise sharply to peak brightness in a few minutes, then decline gradually. The number of flares may increase rapidly over an area of activity. Small flarelike brightenings are always in progress during the more active phase of activity centers. The smaller flares may be classified as subflares. In some instances flares may take the form of prominences, violently ejecting material into the solar atmosphere and breaking into smaller high-speed blobs or clots. Flare activity varies widely between solar activity centers and appears to be a function of the complexity of the magnetic field.

The greatest flare productivity seems to be during the week or 10 days when sunspot activity is at its maximum.

As mentioned in an earlier chapter, solar flare activity causes communication problems affecting all modes of radio transmission.

EARTH

Of the nine planets of our solar system, the earth is third in distance from the sun. Its maximum distance from the sun is 94 million miles in summer; its minimum distance from the sun is 91 million miles in winter. It has an atmosphere more than 600 miles thick.

Motions

The earth is subject to four motions in its movement through space. Only two of these motions are of any importance to meteorology; rotational motion, turning of the earth upon its axis, and revolution around the sun, which refers to the earth's orbit around the sun.

In the first motion the earth rotates on its axis once in 24 hours; one-half of the earth's surface is therefore facing the sun at all times. The side facing the sun is experiencing daylight, and the side facing away from the sun is experiencing darkness, accounting for our day and night. Rotation about its axis takes place in an eastward direction. Thus, the sun rises in the east and sets in the west as illustrated in figure 12-2.

The second motion of the earth is its revolution around the sun. The revolution around the sun and the tilt of the earth on its axis are responsible for our seasons. The earth makes one complete revolution around the sun in approximately 365 1/4 days. The earth's axis is at an angle of 23 1/2° to its plane of rotation. The earth's axis points in a nearly fixed direction in space toward the North Star (Polaris) at all times.

Solstices and Equinoxes

When the earth is in its summer solstice, as shown for June in figure 12-3, the Northern

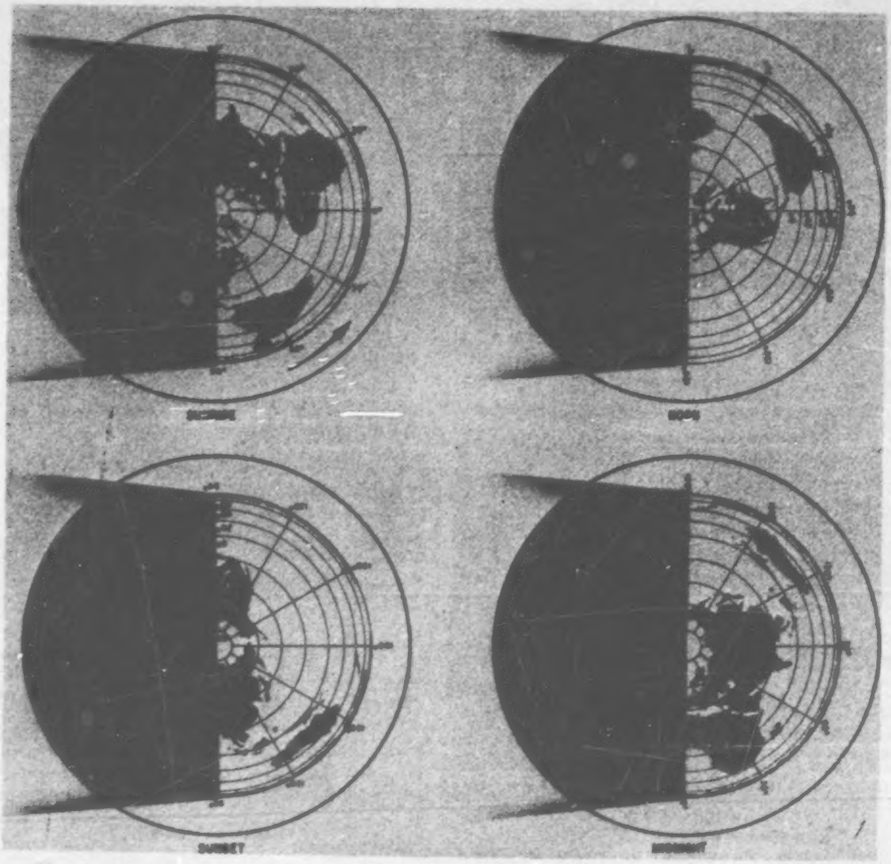


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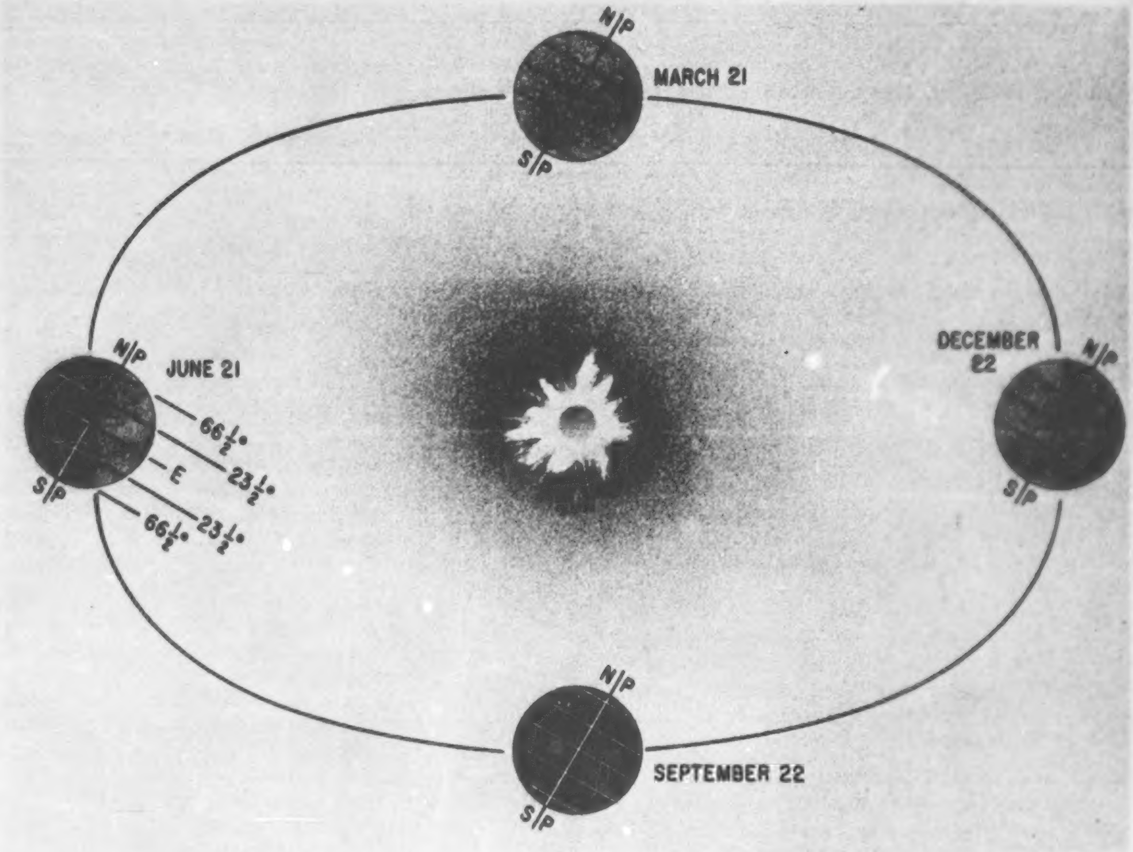
Figure 12-2.—Rotation of the earth about its axis (during equinoxes).



209.3

Figure 12-3.—Revolution of the earth around the sun.

Hemisphere is inclined 23 1/2° TOWARD the sun. This inclination results in more of the sun's rays reaching the Northern Hemisphere than the Southern Hemisphere. On or about June 21, the sun shines OVER the North Pole down the other side to latitude 66 1/2°N (the ARCTIC CIRCLE), and the most perpendicular rays of the sun are received at 23 1/2°N lat (the TROPIC OF CANCER). The Southern Hemisphere is tilted AWAY from the sun at this time, and the sun's rays reach only to 66 1/2°S lat (the ANTARCTIC CIRCLE) and do not go beyond this latitude. The area between the Antarctic Circle and the South Pole is in darkness; the area between the Arctic Circle and the North Pole is receiving the sun's rays for 24 hours each day. Note carefully the shaded and unshaded area of the earth in figure 12-3 for all four positions.

At the equinoxes in March and September, the tilt of the earth's axis is neither toward nor away from the sun. For this reason, the earth receives equal numbers of the sun's rays in both the Northern Hemisphere and the Southern Hemisphere, and the sun's rays shine most perpendicularly at the Equator.

In December, the situation is exactly reversed from that in June. The Southern Hemisphere now receives more of the sun's rays. The most perpendicular rays of the sun are received at 23 1/2°S lat (the TROPIC OF CAPRICORN). The south polar area is completely in sunshine, and the north polar area is completely in darkness.

Since the revolution of the earth around the sun is a gradual process, the charges in the area receiving the sun's rays and the changes in seasons are gradual. However, it is customary and convenient to mark these changes by specific dates and to identify them by specific names. These dates are as follows:

1. March 21. The VERNAL EQUINOX, when the earth's axis is perpendicular to the sun's rays. Spring begins in the Northern Hemisphere and fall begins in the Southern Hemisphere.

2. June 21. The SUMMER SOLSTICE, when the earth's axis is inclined 23 1/2° toward the sun and the sun has reached its northernmost zenith at the Tropic of Cancer. Summer officially commences in the Northern Hemisphere, and winter begins in the Southern Hemisphere.

3. September 22. The AUTUMNAL EQUINOX, when the earth's axis is again perpendicular to the sun's rays. This date marks the beginning of fall in the Northern Hemisphere and spring in the Southern Hemisphere. It is also the date, along with March 21, when the sun reaches its highest position (zenith) directly over the Equator.

4. December 22. The WINTER SOLSTICE, when the sun has reached its southernmost zenith position at the Tropic of Capricorn. It marks the beginning of winter in the Northern Hemisphere and the beginning of summer in the Southern Hemisphere.

In some years, the actual dates of the solstices and the equinoxes vary by a day from the dates given here because the period of revolution is 365 1/4 days, and the calendar year is 365 days, except for leap year when it is 366 days.

Because of its 23 1/2° tilt and its revolution around the sun, the earth is thus marked by five natural light (or heat) zones according to the zone's relative position to the sun's rays. Since the sun is ALWAYS at its zenith between the Tropic of Cancer and the Tropic of Capricorn, this is the hottest zone. It is called the Equatorial Zone, the Torrid Zone, the Tropical Zone, or simply the Tropics.

The zones between the Tropic of Cancer and the Arctic Circle and between the Tropic of Capricorn and the Antarctic Circle are the Temperate Zones. These zones receive sunshine all year, but less of it in their respective winters and more of it in their respective summers.

The zones between the Arctic Circle and the North Pole and between the Antarctic Circle and the South Pole receive the sun's rays only for parts of the year. (Directly at the poles there are 6 months of darkness and 6 months of sunshine.) This, naturally, makes them the coldest zones. They are therefore known as the Frigid or Polar Zones.

RADIATION

The term RADIATION refers to the process by which electromagnetic energy is propagated through space. Radiation moves at the speed of light (186,000 miles per second) and travels in straight lines without the aid of a material medium through which to pass. All of the heat received by the earth is through this process. It is the most important means of heat transfer.

SOLAR RADIATION is defined as the total electromagnetic energy emitted by the sun. The sun's 6000° K surface emits gamma rays, X-rays, ultraviolet, visible light, infrared, heat, and electric waves. Even though the sun radiates in all wavelengths, about half of the radiation is visible light with most of the remainder being infrared.

The earth receives the sun's SHORT WAVE radiation, converts it to LONG WAVE radiation, and reradiates it out to space.

INSOLATION

Insolation (an acronym for INcoming SOLar radiATION) is the rate at which solar radiation is received by a unit horizontal surface at any point on or above the surface of the earth. Henceforth, in this training manual, insolation is used when speaking about incoming solar radiation.

There is a wide variety of differences in the amounts of radiation received over the various portions of the earth's surface. These differences in heating are important and must be measured or otherwise calculated to determine their effect on the weather.

DISPOSITION OF INSOLATION

We will now discuss insolation by describing some of its characteristics and the means of accounting for the differences in the amounts received.

Reflection

Reflection is the process whereby a surface turns back a portion of the incident radiation into the medium through which the radiation came.

Some insolation is reflected by a substance. This means that the electromagnetic waves simply bounce back to space. The earth reflects an average of 36 percent of the insolation. The percent of reflectivity of all wavelengths of a surface is known as its ALBEDO. The earth's average albedo is from 36 to 43 percent. In calculating the albedo of the earth, the assumption is made that the average cloudiness over the earth is 52 percent.

All surfaces do not have the same degree of reflectivity; consequently, they do not have the same albedo. Some examples are as follows:

1. Upper surfaces of clouds: From 40 to 80 percent, with an average of about 55 percent.
2. Snow surfaces: Over 80 percent for cold, fresh snow; as low as 50 percent for old, dirty snow.
3. Land surfaces: From 5 percent for dark forests to 30 percent for dry land.
4. Water surfaces: From 2 percent when the sun is directly overhead to 100 percent when the sun is very low on the horizon. This increase is not linear; after the sun is more than 25° above the horizon, the albedo is less than 10 percent so that, in general, the albedo of water is quite low.

When the earth as a whole is considered, cloud surfaces are most important to determining the earth's albedo.

Absorption

Insolation is absorbed by a substance and is converted to heat. Some substances absorb all radiant energy which reaches them; some absorb none; and some absorb only that in specific wavelengths. The latter is the case with some of the constituents of the atmosphere. The earth's surface absorbs an average of 51 percent of the insolation.

Greenhouse Effect

The atmosphere itself absorbs some of the insolation, but on a selective basis. The shorter wavelengths of insolation pass through the atmosphere to the earth, but earth radiation (longer wavelength infrared radiation) is "trapped" by the atmosphere. Some of this trapped radiation is reradiated to the earth. This causes a higher earth temperature than would occur from direct insolation alone. This is the greenhouse effect, so named because the process is the same as that taking place in a greenhouse: Most of the short-wave solar radiation passes through the glass roof and is absorbed by objects inside. These objects reradiate at their temperatures, which are relatively low compared to the sun's temperature; consequently they emit infrared radiation which is absorbed by the glass. The glass, in turn, radiates energy back into the greenhouse, as well as outward, so that the temperature inside the greenhouse remains warmer than that outside.

Dispersion

Earlier in the chapter it was learned that the earth's axis is inclined at an angle of 23 1/2°. This inclination causes the sun's rays to be received on the surface of the earth at varying angles, depending on the position of the earth. When the sun's rays are not perpendicular to the surface of the earth, they become DISPERSED over a greater area, as can be seen in figure 12-4. Therefore, if the

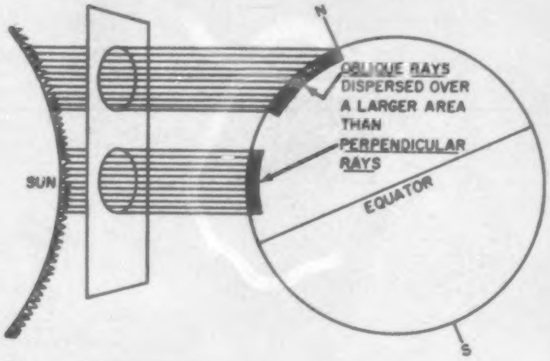


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Figure 12-4.—Differential insolation.

same number of rays has to cover a larger area, they cannot produce as much heat when they are dispersed, and the temperature in the area where the sun's rays are dispersed must be lower. Dispersion of insolation in the atmosphere takes place daily all over the earth due to its rotation.

Dispersion of insolation also takes place with the seasons in all latitudes of the earth, but especially in the latitudes in the polar areas.

Scattering

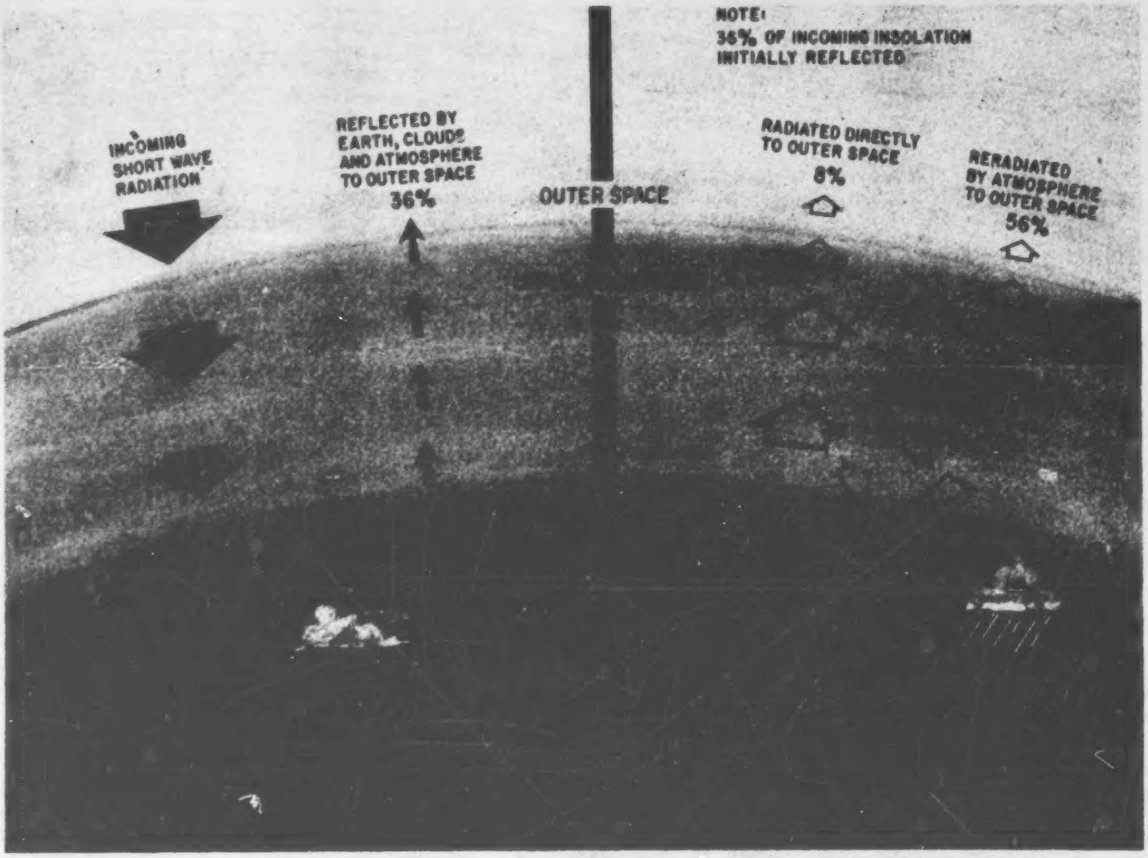
Insolation is also scattered before it reaches the earth's surface. When insolation is scattered in the sky, it causes us to see a blue sky.

RADIATION BALANCE IN THE ATMOSPHERE

The sun radiates insolation to the earth, the earth radiates energy back to space, and the atmosphere radiates energy also. As is shown in figure 12-5, a balance is maintained between incoming and outgoing radiation. This section of the chapter explains the various radiation processes in maintaining this balance.

Terrestrial (Earth) Radiation

Radiation emitted by the earth is almost entirely long-wave radiation. Most of the terrestrial radiation is absorbed by the water vapor in the atmosphere with a small amount


NOTE:
36% OF INCOMING INSOLATION INITIALLY REFLECTED
INCOMING SHORT WAVE RADIATION
REFLECTED BY EARTH, CLOUDS AND ATMOSPHERE TO OUTER SPACE
36%
OUTER SPACE
RADIATED DIRECTLY TO OUTER SPACE
8%
RERADIATED BY ATMOSPHERE TO OUTER SPACE
56%

209.5

Figure 12-5.—Radiation balance in the atmosphere.

(about 8 percent) being radiated directly to outer space. Some is carried aloft by convection and turbulence, and the condensation-precipitation-evaporation cycle (hydrological cycle) carries the remainder into the atmosphere.

Atmospheric Radiation

The atmosphere reradiates to outer space most of the terrestrial radiation (about 43 percent) and insolation (about 13 percent) that it has absorbed. Some of this radiation is emitted downward and is known as COUNTERRADIATION. This radiation is of great importance in the greenhouse effect.

Diffuse Sky Radiation

About 25 percent of the incoming solar radiation is scattered by the atmosphere. About two-thirds of this scattered radiation reaches the earth as diffuse sky radiation. Diffuse sky radiation may account for almost 100 percent of the radiation received by polar stations during winter.

Summary

This is the account of the TOTAL radiation. Some of the radiation makes several trips, being absorbed, reflected, or reradiated by the earth or the atmosphere. Insolation comes into the atmosphere, and all of it is reradiated. How many trips it makes while in our atmosphere does not matter. The direct absorption of radiation by the earth and atmosphere and the reradiations into space balance.

Heat Balance and Transfer in the Atmosphere

Due to the differential insolation (uneven heating) the Tropical atmosphere is constantly being supplied heat and the temperature of the air is thus higher than in areas poleward. Because of the expansion of warm air, this column of air is much deeper than over the poles. At the poles the earth receives little insolation, and the column of air is much shorter and heavier. This differential in insolation sets up a circulation that transports warm air from the Tropics poleward aloft and cold air from the poles equatorward on the surface (fig. 12-6). Modifications to this general circulation are discussed in detail in chapter 13.

Although radiation is considered the most important means of heat transfer, it is not the only method. There are others such as conduction, convection, and advection which also play an important part in the meteorological processes. These will be discussed in more detail later in the chapter.

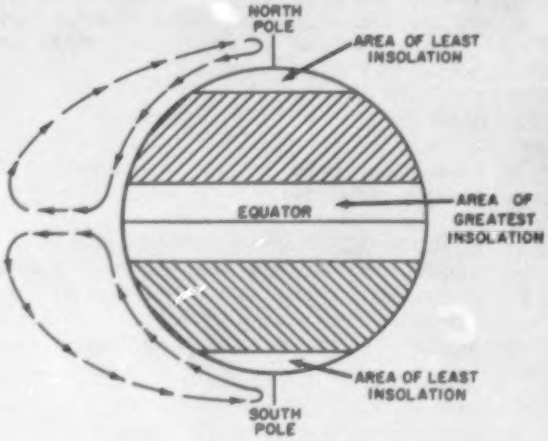


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Figure 12-6.—Beginning of a circulation.

MATTER

DEFINITION

Matter is defined as anything that occupies space and has weight. Matter is around us in some form everywhere in our daily life—the air we breathe, the water we drink, and the food we eat. All of these are various forms of matter. Two basic particles make up the composition of all matter—the atom and the molecule. The molecule is the smallest particle into which matter can be divided without destroying its characteristic properties. In physics, the molecule is the unit of matter. Molecules are composed of one or more atoms. The atom is the smallest particle of certain kinds of matter called chemical elements.

A compound is a substance (or matter) formed by combining two or more elements. Thus, ordinary table salt is a compound formed by combining two elements—sodium and chlorine. Elements and compounds may exist together without forming new compounds. Their atoms do not combine. This is known as a mixture. Air is a familiar mixture. Every sample of air contains several kinds of molecules which are chiefly molecules of the elements oxygen, nitrogen, and argon, together with the compounds of water vapor and carbon dioxide. Ocean water, too, is another mixture, made up chiefly of water and salt molecules, with a smaller number of molecules of many other compounds as well as molecules of several elements.

STATES

Matter is found in one or more of the following three states:

1. Solid. Solids are substances which have a definite volume and shape and will retain their original shape and volume after being moved from one container to another: An example is a block of wood or a bar of metal.

2. Liquid. A liquid has a definite volume, because it is almost impossible to pack it into a smaller space. However, when a liquid is moved from one container to another, it will retain its original volume, but will take on the shape of the container into which it is moved. For example, if a glass of water is poured into a larger bucket or pail, the volume remains unchanged but the liquid will occupy a different space in that it conforms to the walls of the container in which it is poured.

3. Gas. Gases have neither a definite shape nor a definite volume. They will not only take on the shape of the container into which they are placed but will expand and fill it, no matter what the volume of the container.

Since gases and liquids flow easily, they are both called fluids. Moreover, many of the laws of physics which apply to liquids apply equally as well to gases.

PHYSICAL PROPERTIES OF METEOROLOGICAL SIGNIFICANCE

From our definition of matter (anything that occupies space and has weight), it can be said that all kinds of matter have certain properties in common. These properties are inertia, mass, gravitation, weight, volume, and density. These properties are covered briefly in this section and are called the general properties of matter.

Inertia

This property of matter is perhaps the most fundamental of all attributes of matter. In short, it is the tendency for an object to stay at rest if it is in a position of rest, or to continue in motion if it is moving. Inertia makes bodies hard to start and hard to stop.

Mass

Mass is the quantity of matter contained in a substance. This property does not vary unless matter is added to or subtracted from the substance. For example, a sponge can be compressed or allowed to expand back to its original shape and size, but the mass does not change. The mass will remain the same on the earth as on the sun or moon, or at the bottom of a valley or the top of a mountain. Only if something is taken away or added to it is the mass changed. Later in the chapter its meaning will have a slightly different connotation.

Gravitation

Every body attracts or pulls upon other bodies. In other words, all matter has gravitation. One of Newton's laws states that the force of attraction between two bodies is directly proportional to the product of their masses and inversely proportional to the square of the distance between their two centers. Therefore, a mass will have less gravitational pull on it at the top of a mountain than it would at sea level because the center is displaced farther away from the gravitational pull of the center of the earth. However, the mass remains the same even though the gravitational pull is different. Gravity also varies with latitude, being slightly less at the Equator than at the poles due to a greater distance from the center of the earth.

Weight

The weight of an object is a measure of gravitational attraction and depends upon the mass or quantity that it contains and the amount of gravitational attraction the earth has for it. Weight is a force, and as such it should be expressed in units of force.

Since gravity varies with latitude and height above sea level, so must weight vary with the same factors. Thus, you will weigh more at the poles than at the Equator and more at sea level than atop a mountain. In a comparison of mass and weight, mass will remain constant no matter where it is, but weight will vary with latitude and height above sea level.

Volume

Volume is the measure of the amount of space which matter occupies. The volume of rectangular objects is found directly by obtaining the product of their length, width, and depth. For determining the volume of liquids and gases, special graduated containers are used.

Density

The mass of a unit volume of a substance or mass per unit volume is called density. Usually we speak of substances being heavier or lighter than another when comparing equal volumes of the two substances.

Since density is a derived quantity, the density of an object can be computed by dividing its mass (or weight) by its volume. The formula for determining the density of a substance is

$$D = \frac{M}{V}$$

where D stands for density, M for mass, and V for volume.

From this formula, it is obvious that with mass remaining unchanged, an increase in volume causes a decrease in density, and a decrease in volume causes an increase in density.

The density of gases is derived from the same basic formula as the density of a solid. Pressure and temperature also affect the density of gases. This effect is discussed later in this chapter under gas laws. Another notable effect is the moisture content of a gas.

SYSTEM OF MEASUREMENTS

To properly relate to the field of meteorology, the Aerographer should have a basic understanding of the science of measurement (metrology). When you can measure what you are talking about and present it in numerical values, you then have a knowledge of your subject. From early times requirements for having a measurement system were needed. There are many such systems throughout the world today; but, on an international scale, three fundamental quantities, length (meter/metre), mass (kilogram), and time (second), have been recognized for use in science and research. It is for this reason that the Metric System (CGS, centimeter-gram-second) will be discussed in the following paragraphs, with brief points of discussion on the English System (FPS, foot-pound-second).

CGS AND FPS SYSTEMS

The metric system is a decimal system similar to that used in the money system of the United States, in that each unit is one-tenth the size of the next larger unit of measure. It is the system most widely used, and it is not improbable that before many years this system will receive worldwide adoption.

The metric system is not difficult to learn. The meter is the unit of length, and the gram is the unit of mass. The common subdivisions of each of these units is then broken down by the use of certain prefixes such as centi—meaning one one-hundredth—and milli—meaning one one-thousandth. The most common multiple for these units is formed by using the prefix kilo which means one thousand. (See table 12-1.)

A meter is equivalent to approximately 39.37 inches. The prefixes are used to indicate larger or smaller units of the meter.

Other quantities derived from length are the area and the volume. The standard unit of measure for area is the square centimeter, or cm^2. For volume, the unit most used is a cube with an edge of unit length. In the English system, volume is usually measured in cubic feet or cubic inches. Thus, the unit is a cube 1 foot or 1 inch on each edge. In the metric system the cubic centimeter or cubic meter is used. Another unit commonly used in the metric system is the LITER. The liter is the volume of a cube 10 centimeters on each edge. The liter, therefore, contains 1,000 cubic centimeters.

Since mass in the CGS system is measured in grams, and the unit volume in the CGS system is 1 cubic centimeter, density may be

Table 12-1. — Common prefixes used in the Metric System.

Tera - meaning 10^{12}	Pico - meaning 10^{-12}
Giga - meaning 10^{9}	Nano - meaning 10^{-9}
Mega - meaning 10^{6}	Micro - meaning 10^{-6}
Kilo - meaning 10^{3}	Milli - meaning 10^{-3}
Hecto - meaning 10^{2}	Centi - meaning 10^{-2}
Decka - meaning 10^{1}	Deci - meaning 10^{-1}

NOTE: It then can be seen that a "KILOMETER" equals 1,000 meters and a "MILLIMETER" .001 of a meter, etc. These prefixes can be used with all kinds of units, such as, CENTIMETER, KILOGRAMS, and MICROSECONDS.

expressed as grams per cubic centimeter. We then have the equation

$$D = \frac{g}{cm^3}$$

In the metric system, 1 cubic centimeter of water has a mass of approximately 1 gram; therefore, the density of water is given as 1 gram per cubic centimeter or 1 g/cm^3. In the English system, the density of water is 62.4 pounds per cubic foot, or 62.4 lb/ft^3.

Force is measured in dynes. A dyne is the force that will give a mass of 1 gram an acceleration of 1 centimeter per second per second; this is commonly written as gm cm per sec^2, gm cm/sec/sec, or gm cm/sec^2. The force necessary to accelerate 1 gram 980.665 cm/sec^2 at 45° latitude would be 980.665 dynes.

Measures of weight in the metric system are formed by adding the Greek and Latin prefixes to the gram. There are approximately 454 grams to a pound. The kilogram is 1,000 grams and is equivalent to about 2.2 pounds.

In both the English and the metric systems the second is the standard unit of time.

For more detailed conversion factors commonly used in meteorology and oceanography, refer to Smithsonian Meteorological Tables.

PRESSURE

Since pressure is one of the most important parameters in meteorology, knowledge of its atmospheric structure and the forces which cause it to change is needed to understand how it affects the earth's weather patterns.

DEFINITION

Pressure is defined as force per unit area. Atmospheric pressure is the force per unit area exerted by the atmosphere in any part of the atmospheric envelope. Therefore, the greater the force exerted by the air for any given area, the greater the pressure. Although the pressure varies on a horizontal plane from day to day, the greatest pressure variations are with changes in altitude. Nevertheless, horizontal variations of pressure are important in meteorology because they cause or help to cause good and bad weather.

As previously mentioned, pressure is force, and force is related to acceleration and mass by Newton's second law. This law states that acceleration of a body is directly proportional to the force exerted on that body and inversely proportional to the mass of that body. It may be expressed as

$$a = \frac{F}{m}$$

where "a" is the acceleration, "F" is the force exerted, and "m" is the mass of the body. This is probably the most important equation in the mechanics of physics dealing with force and motion. It is usually stated in the form ($F = ma$). NOTE: Be sure to use units of mass and not units of weight when applying this equation.

STANDARDS OF MEASUREMENT

Atmospheric pressure is normally measured in meteorology by the use of a mercurial or aneroid barometer. Pressure is measured in many different units. One atmosphere of pressure is 29.92 inches of mercury, 760 millimeters of mercury, 1,013.25 millibars, 14.7 pounds per square inch, or 1,033 grams per square centimeter. These measurements are made under standard conditions.

STANDARD ATMOSPHERE

The ICAO (International Civil Aeronautical Organization) Standard Atmosphere assumes a mean sea level temperature of 15° C, a standard sea level pressure of 1,013.25 millibars or 29.92 inches of mercury, a temperature lapse rate (decrease) of 0.65° C per 100 meters up to 11 kilometers, and a tropopause and stratosphere temperature of -56.5° C.

In the Naval Weather Service, pressure measurements are expressed in millibars and inches of mercury.

VERTICAL DISTRIBUTION

Pressure at any point in a column of water, mercury, or any fluid, depends upon the weight of the column above that point.

Air pressure at any given altitude within the atmosphere is determined by the weight of the atmosphere pressing down from above. Therefore, the pressure decreases with altitude because the weight of the atmosphere decreases.

It has been found that the pressure decreases by half for each 18,000-foot increase in altitude. Thus, at 18,000 feet one can expect an average pressure of about 500 millibars (7.35 pounds per square inch), and at 36,000 feet a pressure of only 250 millibars (3.68 pounds per square inch), etc. Therefore, it may be concluded that atmospheric pressures are greatest at lower elevations because the total weight of the atmosphere is greatest at these points.

There is a change of pressure whenever either the mass of the atmosphere or the accelerations of the molecules within the atmosphere are changed.

Although altitude exerts the dominant control, temperature and moisture alter pressure at any given altitude, especially near the earth's surface where heat and humidity are most abundant. The pressure variations produced by heat and humidity (with heat operating as the senior partner) cause the turbulence and wind that help to make our weather.

PASCAL'S LAW

Pascal's law relative to the behavior of FLUIDS under pressure applies, of course, to GASES under pressure, all of which means that a gas transmits undiminished pressure in all directions and on all parts of the enclosing wall. The law states that when an external pressure is applied to any confined fluid at rest, the pressure is increased at every point in the fluid by the amount of external pressure applied. This means that the pressure of the atmosphere is exerted not only downward on the surface of an object, but also in all directions against a surface which is exposed to the atmosphere.

TEMPERATURE

One of the most important properties of the atmosphere is its ability to absorb and lose heat. The heating and cooling of the atmosphere exert a tremendous influence on the processes that determine the weather. Consequently, temperature is one of the principal concerns of the Aerographer's Mate. It is necessary to know the meaning of temperature, the scales and instruments used in its measurement, and the important temperature values. Procedures for observing temperature were discussed in earlier chapters.

DEFINITION

Temperature may be regarded as a measure of molecular motion determined from an absolute zero point at which all molecular motion stops. Temperature may be defined as the degree of hotness or coldness, or it may be considered as a measure of heat intensity. This being the case, we may conveniently measure temperature in several different ways.

One way of measuring temperature is by means of a liquid thermometer. The changes in volume of certain sensitive substances, such as alcohol or mercury, which expand greatly with an increase in molecular activity (temperature increase) and contract greatly when the molecular activity slows down (temperature decreases), are observed.

Another way to measure temperature is to place substances, usually metals, next to one another and note the difference in their expansion or contraction. Each substance has an expansion coefficient which is based on the amount it expands per degree of temperature increase. One metal alone can be used to measure temperature; but since the expansion is usually small, it is very difficult to get an easy and accurate measurement. Two metals welded together make the measurement easier because the strip with the lesser expansion coefficient bends the one with the greater; the curve of bending is easily magnified, thus affording an easy and accurate measure of temperature. Welded strips of two dissimilar metals are called bimetallic strips.

There are other methods, such as measuring the electrical resistance of a substance (resistance changes with temperature; therefore, temperature can be found by finding the resistance), spectral analysis, measurements of the speed of sound, and measurement of electromagnetic radiation.

Temperature measurement devices used most extensively are those dealing with a confined substance (alcohol or mercury), differences in linear expansion (bimetallic strip), and changes in electrical resistance (radiosondes, AN/GMQ-14, and AN/GMQ-29).

TEMPERATURE SCALES

Long ago it was recognized that uniformity in the measurement of temperature was essential. It would be foolhardy to rely on such subjective judgments of temperature as "cool," "cooler," and "coolest"; therefore, arbitrary scales were devised. Some of them are described in this section. They are Fahrenheit, Celsius, and absolute (Kelvin) scales. These are the scales in use by the Naval Weather Service as well as most meteorological services of all the countries in the world. (See table 12-2.)

Fahrenheit Scale

The Fahrenheit scale was invented by Gabriel Daniel Fahrenheit about 1710. He was the first to use mercury in a thermometer. The Fahrenheit scale has 180 divisions or degrees between the freezing point (32° F) and boiling point (212° F) of water.

Celsius Scale

The Celsius scale was devised by Anders Celsius during the 18th century. This scale has reference points with respect to water of 0° C for freezing and 100° C for boiling.

It should be noted that many publications still refer to the "centigrade temperature scale". Although different in name, it is the same as the Celsius temperature scale now in universal use.

Absolute Scale (Kelvin)

Another scale in wide use by scientists in many fields is the absolute scale or Kelvin scale. It was developed by Lord Kelvin of England. On this scale the freezing point of water is 273° A (or K), and the boiling point of water is 373° A (or K). The absolute zero value is considered to be a point at which theoretically no molecular activity exists. This places the absolute zero at a minus 273° on the Celsius scale, since the degree divisions are equal in size on both scales. The absolute zero value on the Fahrenheit scale falls at minus 459.6° F.

Scale Conversions

Since all three scales are used in the Naval Weather Service, it is often necessary to change the temperature value of one scale to that of another scale. Generally a temperature conversion table is used (Table 12-2) or a temperature computer. If these are not available, the Aerographer must then use one of the following mathematical methods to convert one scale to another.

Mathematical Methods

It is helpful to note that there are 100 divisions between the freezing and boiling points of water on the Celsius scale, whereas there are 180 divisions between the same references on the Fahrenheit scale. Therefore, one degree on the Celsius scale equals nine-fifths degree on the Fahrenheit scale. In converting Fahrenheit values to Celsius values the formula is:

$$C = (F - 32^\circ) \times \frac{5}{9}$$

In converting Celsius values to Fahrenheit values the formula is:

$$F = \left(\frac{9}{5} \times C\right) + 32^\circ$$

One way to remember when to use 9/5 and when to use 5/9 is to keep in mind that the Fahrenheit scale has more divisions than the Celsius scale. In going from Celsius to Fahrenheit, multiply by the ratio that is larger;

Table 12-2.—Temperature conversion scale

°C	°F[1]	°K
-40	-40.0	233
-39	-38.0	234
-38	-36.5	235
-37	-34.5	236
-36	-33.0	237
-35	-31.0	238
-34	-29.0	239
-33	-27.5	240
-32	-25.5	241
-31	-24.0	242
-30	-22.0	243
-29	-20.0	244
-28	-18.5	245
-27	-16.5	246
-26	-15.0	247
-25	-13.0	248
-24	-11.0	249
-23	-09.5	250
-22	-07.5	251
-21	-06.0	252
-20	-04.0	253
-19	-02.0	254
-18	-00.5	255
-17	+01.5	256
-16	+03.0	257
-15	+05.0	258
-14	+07.0	259
-13	+08.5	260
-12	+10.5	261
-11	+12.0	262
-10	+14.0	263
-09	+16.0	264
-08	+17.5	265
-07	+19.5	266
-06	+21.0	267
-05	+23.0	268
-04	+25.0	269
-03	+26.5	270
-02	+28.5	271
-01	+30.5	272
00	+32.0	273
+01	+33.5	274
+02	+35.5	275
+03	+37.5	276
+04	+39.5	277
+05	+41.0	278
+06	+43.0	279
+07	+44.5	280
+08	+46.5	281
+09	+48.0	282
+10	+50.0	283
+11	+52.0	284
+12	+53.5	285
+13	+55.5	286
+14	+57.0	287
+15	+59.0	288
+16	+61.0	289
+17	+62.5	290
+18	+64.5	291
+19	+66.0	292
+20	+68.0	293
+21	+70.0	294
+22	+71.5	295
+23	+73.5	296
+24	+75.0	297
+25	+77.0	298
+26	+79.0	299
+27	+80.5	300
+28	+82.0	301
+29	+84.0	302
+30	+86.0	303
+31	+88.0	304
+32	+89.5	305
+33	+91.5	306
+34	+93.0	307
+35	+95.0	308
+36	+96.5	309
+37	+98.0	310
+38	+100.5	311
+39	+102.0	312
+40	+104.0	313
+41	+106.0	314
+42	+107.5	315
+43	+109.5	316
+44	+111.0	317
+45	+113.0	318
+46	+115.0	319
+47	+116.5	320
+48	+118.5	321
+49	+120.0	322
+50	+122.0	323
+51	+124.0	324
+52	+125.5	325
+53	+127.5	326
+54	+129.0	327
+55	+131.0	328
+56	+133.0	329
+57	+134.5	330
+58	+136.5	331
+59	+138.0	332
+60	+140.0	333

[1] Fahrenheit temperatures are rounded to the nearest 0.5 degree. For a more exact conversion, utilize the psychrometric computer or the mathematical method.

in going from Fahrenheit to Celsius, use the smaller ratio.

Another method of converting temperatures from one scale to another is the decimal method. This method uses the ratio 1° C equals 1.8° F. To find Fahrenheit from Celsius, multiply the Celsius value by 1.8 and add 32. To find Celsius from Fahrenheit, subtract 32 from the Fahrenheit and divide the remainder by 1.8.

A third method of temperature conversion is based on the fact that the Fahrenheit and Celsius scales both register the same temperature at -40°; that is, -40° F equals -40° C. This method of conversion, sometimes called the "40 rules," proceeds as follows:

1. Add 40 to the temperature which is to be converted. Do this whether the given temperature is Fahrenheit or Celsius.
2. Multiply by 9/5 when changing Celsius to Fahrenheit; by 5/9 when changing Fahrenheit to Celsius.
3. Subtract 40 from the result of step 2. This is the answer.

Remember that the multiplying ratio for converting F to C is 5/9, rather than 9/5. Also remember to always ADD 40 first, then multiply, then SUBTRACT 40, regardless of the direction of the conversion.

To change a Celsius reading to an absolute value, add the Celsius reading to 273° algebraically. For example, minus 35° C is equivalent to 238° absolute, arrived at by adding minus 35° C to 273°.

To change a Fahrenheit reading to an absolute value, first convert the Fahrenheit reading to its equivalent Celsius value, which is then added algebraically to 273°. Consequently, 50° F is equivalent to 283° absolute, arrived at by converting 50° F to 10° C and then adding the Celsius value algebraically to 273°.

VERTICAL DISTRIBUTION

The earth's atmosphere is divided into layers or zones according to various distinguishing features, as illustrated in figure 12-7. The temperatures shown here are generally based on the latest "U.S. Extension to the ICAO Standard Atmosphere" and are representative of mid-latitude conditions. The extension shown in the insert is speculative. These divisions are for reference of thermal structure (Lapse Rates) or other significant features and are not intended to imply that these layers or zones are independent domains. The earth is surrounded by one atmosphere, not by a number of subatmospheres.

Terms

In discussing vertical distribution of the earth's atmosphere, several terms are used that should be understood by the Aerographer.

LAPSE RATE.—In general, lapse rate is the rate of decrease in the value of any meteorological element with elevation. However, it is usually restricted to the rate of decrease of temperature with elevation; thus, the lapse rate of the temperature is synonymous with the vertical temperature gradient. The temperature lapse rate is usually positive, which means that the temperature decreases with elevation.

INVERSION.—Inversions describe the atmospheric conditions when the temperature increases with altitude, rather than decreases as is usual. Inversions result from the selective absorption of the earth's radiation by the water vapor in the air, and also from the sinking or subsidence of air, which results in its compression and, therefore, heating. Either effect alone may cause an inversion; combined, the inversion would be stronger.

Inversions are a frequent occurrence, especially at night, in the Tropics, and in the Polar regions. For night conditions all over the world, for the polar regions, and for the tropical regions, it may be said that inversions in the lower levels are the rule rather than the exception.

ISOTHERMAL.—In the isothermal lapse rate, no cooling or warming is noted, and the rate is zero with height.

These three general temperature changes through a given layer of air with height, should not be confused with the rate of cooling of an air parcel ascending through a layer, which will be discussed in the adiabatic processes later in this chapter.

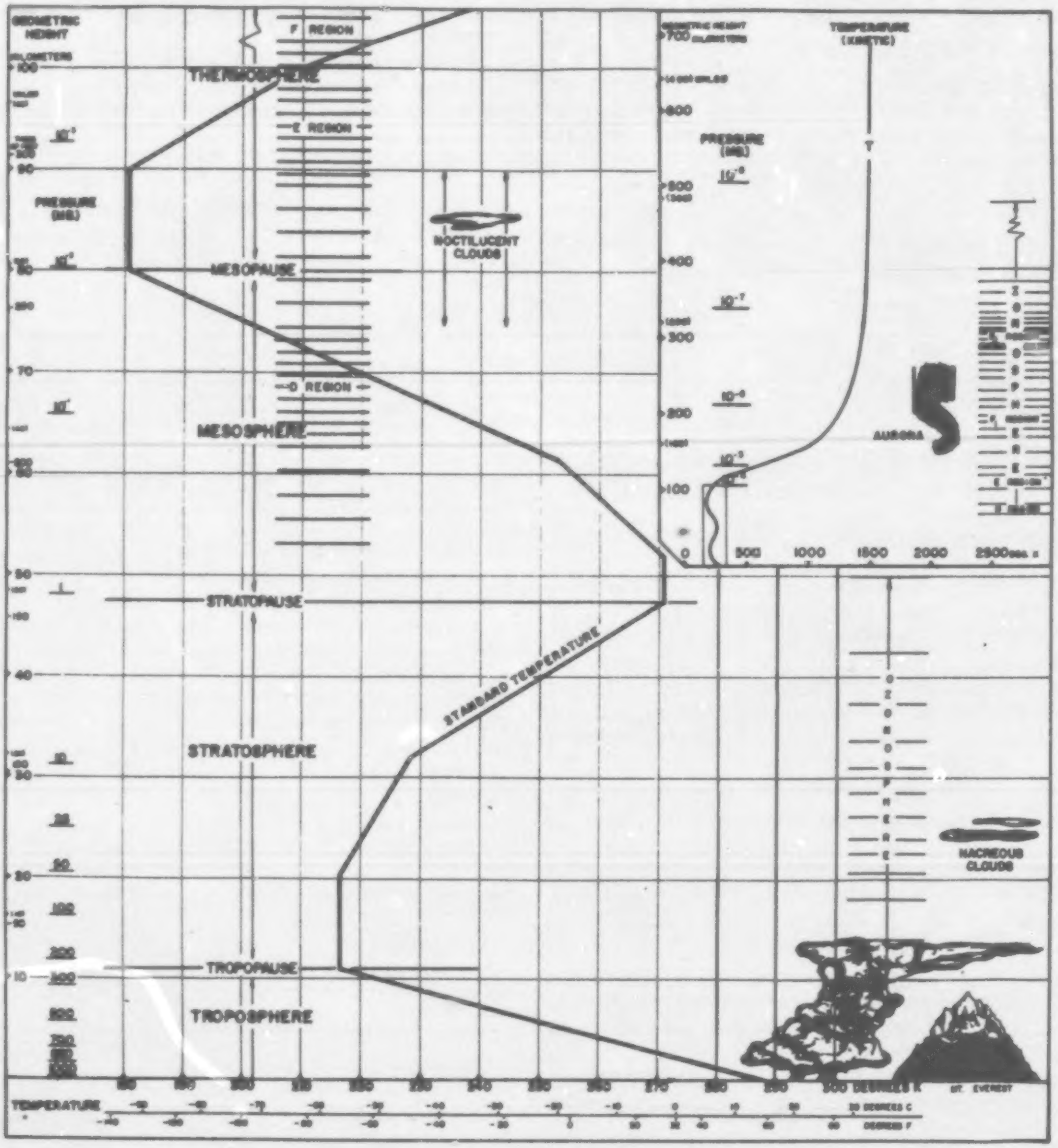

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Figure 12-7.—The Earth's Upper Atmosphere.

Layers of the Atmosphere

The layers and zones will be discussed under two separate classifications. One is the METEOROLOGICAL classification which defines zones according to their significance for the weather, and the other is the ELECTRICAL classification which defines zones according to electrical characteristics of gases of the atmosphere.

METEOROLOGICAL CLASSIFICATION.—In the meteorological classification (commencing with the earth's surface and proceeding upward) are encountered the troposphere, tropopause, stratosphere, stratopause, mesosphere, mesopause, thermosphere, and the exosphere. These classifications are based on temperature characteristics.

Troposphere.—The troposphere is the layer of air enveloping the earth immediately above the earth's surface. It is approximately 5 1/2 miles (29,000 ft or 9 km) thick over the poles, about 7 1/2 miles (40,000 ft or 12.5 km) thick in the mid-latitudes, and about 11 1/2 miles (61,000 ft or 19 km) thick over the Equator. The figures for thickness are average figures, they change somewhat from day to day and from season to season. The troposphere is thicker in summer than in winter and is thicker during the day than during the night. All weather, as we know it, occurs in the troposphere.

The troposphere is composed of a mixture of several different gases, By volume, the composition of dry air in the troposphere is as follows: 78 percent nitrogen, 21 percent oxygen, nearly 1 percent argon, and about 0.03 percent carbon dioxide. In addition, it contains minute traces of other gases, such as helium, hydrogen, neon, krypton, and others.

The air in the troposphere also contains a variable amount of water vapor. The maximum amount of water vapor that the air can hold depends on the temperature of the air and the pressure; that is, the higher the temperature, the more water vapor it can hold at a given pressure.

The air also contains variable amounts of impurities, such as dust, salt particles, soot, and chemicals. There impurities in the air are important because of their effect on visibility and especially because of the part they play in the condensation of water vapor. If the air were absolutely pure, there would be little condensation; these minute particles act as nuclei for the condensation of water vapor. Nuclei which have an affinity for water vapor are called HYGROSCOPIC NUCLEI.

The temperature in the troposphere usually decreases with height, but there may be inversions for relatively thin layers at any level.

Tropopause.—The tropopause is a transition layer between the troposphere and the stratosphere. It is not uniformly thick, and it is not continuous from the Equator to the poles. In each hemisphere the existence of three distinct tropopauses is generally agreed upon—one in the subtropical latitudes, one in middle latitudes, and one in subpolar latitudes. These may overlap or may be folded.

The tropopause is characterized by little or no increase or decrease of temperature with increasing altitude. The composition of gases is about the same as that for the troposphere. However, water vapor is found only in very minute quantities at the tropopause and above it.

Stratosphere.—The stratosphere directly overlies the tropopause and extends to about 30 miles (160,000 ft). Temperature varies little with height in the stratosphere through the first 30,000 feet; however, in the upper portion the temperature increases approximately linearly to values nearly equal to surface temperatures. This increase in temperature through this zone is attributed to the presence of ozone which absorbs most of the incoming ultraviolet radiation.

Stratopause.—The stratopause is the top of the stratosphere. It is the zone marking another reversal of temperature with increasing altitude.

Mesosphere.—The mesosphere is a layer approximately 20 miles (100,000 ft) thick which directly overlies the stratopause. The temperature decreases with height.

Mesopause.—The mesopause is the thin boundary zone between the mesosphere and the thermosphere. It is marked by a reversal of temperature; i.e., temperature again increases with altitude.

Thermosphere.—The thermosphere, a second region in which the temperature increases with height, extends from the mesopause to outer space.

Exosphere.—The very outer limit of the earth's atmosphere is regarded as the exosphere. It is the zone in which gas atoms are so widely spaced that they rarely collide with one another and have individual orbits around the earth. It is believed not to be of meteorological significance.

ELECTRICAL CLASSIFICATION.—The primary concern with the electrical classification is the effect on communications and radar. The electrical classification outlines three zones—the troposphere, the ozonosphere, and the ionosphere.

Troposphere.—In the troposphere, the primary emphasis is on the formation of inversions of temperature; that is, the increase of temperature with gain in altitude and on variation in moisture with altitude. Certain conditions cause significant bending or refraction of radio and radar waves. Under certain circumstances the range of communication and radar is thereby increased, and under other circumstances the range is shortened.

Ozonosphere.—This layer is nearly coincident with the stratosphere. As was discussed earlier in this section, the ozone found in this zone is responsible for the increase in temperature with height in the stratosphere.

Ionosphere.—The ionosphere extends from about 40 miles (200,000 ft) to an indefinite height. Ionization of air molecules through this zone provides conditions that are favorable for radio propagation. This zone is subdivided into the D, E, and F regions. The F regions are considered the most important for increasing communication capabilities.

HEAT TRANSFER

The atmosphere is constantly gaining and losing heat, and heat is being transported from one part of the world to the other by wind movements. It is due to the inequalities in gain and loss of heat that the air is almost constantly in motion. The motions and heat transformations are directly expressed by wind and weather.

Methods

In meteorology, one is concerned with four methods of heat transfer. They are conduction, convection, advection, and radiation. Heat is transferred from the earth directly to the atmosphere by radiation, conduction, and advection, and within the atmosphere by radiation, conduction, and convection. Advection, a form of convection, is used in a special manner in meteorology; it is discussed as a separate method of heat transfer. As radiation was discussed earlier in the chapter, this section will concern only conduction, convection, and advection.

CONDUCTION.—Conduction is the transfer of heat from warmer to colder matter by contact. Although of secondary importance in the heating of the atmosphere, it is a means by which air close to the surface of the earth heats during the day and cools during the night. Even if air is a poor conductor (as shown by the use of dead airspace in Thermopane glass and the airspaces used as insulation in buildings), the heating and cooling of air at the immediate surface of the earth are accomplished by conduction.

CONVECTION.—Convection is the method of heat transfer in a fluid resulting in transport and mixing of the properties of that fluid. Visualize a pot of boiling water. The water at the bottom of the pot is heated by conduction. It becomes less dense and rises. Cooler and denser water from the sides and the top of the pot rushes in and replaces the rising water. In time, the water is thoroughly mixed. As long as heat is applied to the pot, the water continues to transfer heat by convection. The transfer of heat by convection in this case applies only to what is happening to the water in the pot. In meteorology, the term "convection" is normally applied to vertical transport.

Vertical transfer of heat in the atmosphere works in a similar manner; warmer, less dense air rises and is replaced by descending cooler, denser air, which in turn, acquires heat.

Convection occurs regularly in the atmosphere, resulting in turbulent air and large cumulus-type clouds when sufficient moisture is present. The specifics of convection were discussed in greater detail as it pertained to the SKEW-T Log "P" Diagram in chapter 10 of this manual.

ADVECTION.—Advection is really a form of convection, but in meteorology it means the transfer of heat or other properties along the HORIZONTAL. Convection is the term reserved for the VERTICAL transport of heat. Henceforth in this training manual the words "convection" and "advection" are used to mean the vertical and horizontal transfer of atmospheric properties, respectively.

Horizontal transfer of heat is accomplished by motion of the air from one latitude and longitude to another. It is of major importance in the exchange of air between polar and equatorial regions. Much more heat is transported from place to place by the process of advection than by any of the other methods of heat transfer. This is easily understood when you think of the fact that the air is almost always in motion at all levels of the atmosphere.

Transfer of heat by advection is accomplished not only by the transport of warm air, but also by the transport of water vapor which releases heat when condensation occurs.

Specific Heat

The specific heat of a substance shows how many calories of heat it takes to raise the temperature of 1 gram of that substance 1° C. Since it takes 1 calorie to raise the temperature of 1 gram of water 1° C, the specific heat of water is 1. The specific heat of a substance plays a tremendous role in meteorology because it is tied directly to temperature changes. For instance, the specific heat of the earth in general is 0.33. This means it takes only 0.33 calorie to raise the temperature of 1 gram of earth 1° C. Stated another way, the earth heats and cools three times as fast as water.

From this the Aerographer's Mate can see that ocean weather is milder and less extreme in temperature than continental weather because it takes 3 times as long (or 3 times as much heat/cooling) for water to both heat and cool.

The specific heat of various land surfaces is also different, though the difference between one land surface and another is not as great as between land and water. Dry sand or bare rock has the lowest specific heat. Forest areas have the highest specific heat. This difference in specific heat is another cause for differences in temperature for areas of different types of surfaces which are only a few miles apart.

The specific heat of ice is 0.421 and that of steam is 0.502. These specific heats are reflected in the thermal history of 1 gram of ice as shown in figure 12-8. They also point out the tremendous amount of energy involved in the fusion, sublimation, and vaporization processes in the atmosphere.

Energy cannot be created or destroyed; however, it can be transformed from one type of energy into another. Even the amount that seems to be lost can be accounted for in the form of light, sound, heat, and the like.

PRESSURE-TEMPERATURE-DENSITY RELATIONSHIP

The conditions under which gases must be compared, densities determined, and gas constants derived are known as the standard conditions for gases. The standard conditions are a pressure of 760 millimeters of mercury (1,013.25 mb) and a temperature of 0° C, sometimes referred to as STP (standard temperature and pressure).

KINETIC THEORY OF GASES

The kinetic (motion) theory of gases is very helpful in understanding the behavior of gases. Gases, like some other substances, consist of molecules which have no inherent tendency to stay in one place as do the molecules of a solid. Instead, the molecules of gas, since they are smaller than the space between them, move about at random (but in straight lines until they collide with each other or with other obstructions). When gas is enclosed, its pressure depends on the number of times the molecules strike the surrounding walls. The number of blows which the molecules strike per second against the walls remains constant as long as the temperature and the volume remain constant.

If the volume (the space occupied by the gas) is decreased, the number of blows against the wall is increased, thereby increasing the pressure, the temperature remaining constant. Temperature is a measure of the molecular activity of the gas molecules and a measure of the internal energy of a gas. When the temperature is increased, there is a corresponding increase in the speed of the molecules; they strike the walls at a faster rate, thereby increasing the pressure, provided the volume remains constant.

Therefore, there is a close relationship of volume, pressure, and density of gases.

GAS LAWS

The laws governing the behavior of gases and mixtures of gases are given in the following sections.

Boyle's Law

Boyle's law states that the volume of a gas is inversely proportional to its pressure, provided the temperature remains constant. This means that if the volume is halved, the pressure is doubled.

The formula for Boyle's law is as follows:

$$VP = V'P'$$

For example, assume 20 cm^3 of gas has a pressure of 1,000 mb. If the pressure is increased to 1,015 mb and the temperature remains constant, the new volume will be 19.71 cm^3. Applying the formula, we find

$$20 \times 1{,}000 = V' \times 1{,}015$$

$$V' = \frac{20{,}000}{1{,}015}$$

$$V' = 19.71 \text{ cm}^3$$

Charles' Law

In the section on the kinetic theory of gases, it was explained that the temperature of a gas is a measure of the average speed of the molecules of the gas. It was also shown that the pressure the gas exerts is a measure of the number of times per second that the molecules strike the walls of the container and the speed at which they strike it. It then can easily be seen that if the temperature of a gas in a closed container is raised, the speed of the molecules within the gas increases. This causes the molecules to strike the sides of the container more times per second and with more force, since they are moving faster. Thus, by increasing the temperature, the pressure is increased. This is stated by charles' law in the following manner: If the volume of an enclosed gas remains constant, the pressure is directly proportional to the absolute temperature. Therefore, if the absolute temperature is doubled, the pressure is doubled; if the absolute temperature is halved, the pressure is halved. The formulas for Charles' law are $PT' = P'T$, where volume is constant, and $VT' = V'T$ where pressure in constant.

For example, assume that 10 cm^3 of a gas have a temperature of 200° absolute. If the temperature is increased to 300° absolute, the volume is 15 cm^3. Applying the formula, we find

$$10 \times 300 = V' \times 200$$

$$V' = \frac{3{,}000}{200}$$

$$V' = 15\text{cm}^3$$

or applying T' and P', the same type relationship can be computed.

Universal Gas Law

The universal gas law is a combination of Boyle's law and Charles' law. It states that the product of the initial pressure, initial volume, and new temperature (absolute scale) of an enclosed gas is equal to the product of the new pressure, new volume, and initial temperature. The formula is $PVT' = P'V'T$.

For example assume the pressure of 500 cm^3 volume of gas is 600 mb and the temperature is 30° C. (303° absolute). If the temperature is increased to 45° C (318° absolute) and the volume is decreased to 250 cm^3, the pressure of the volume will be 1,259.4 mb. Applying the formula, we find

$$600 \times 500 \times 318 = P' \times 250 \times 303$$

$$P' = \frac{95{,}400{,}000}{75{,}750}$$

$$P' = 1{,}259.4 \text{ mb}$$

Equation of State

The Equation of State is a general formula which gives the same information as Boyle's law and Charles' law. It involves a gas constant, which is a value assigned each gas. For instance, the gas constant of air is 2,870 when the pressure is expressed in millibars, and the density is expressed in metric tons per cubic meter. The constant may be expressed differently, depending on the system of units used. The following formula is an expression of the equation:

$$P = \rho RT$$

P—pressure in millibars
ρ—density
R—gas constant
T—temperature (absolute)

From this relationship, we can draw the following conclusions:

1. A change in pressure, density (mass or volume), or temperature requires a change in one or both of the others.

2. An increase in atmospheric pressure results in an increase in atmospheric density. Conversely, a decrease in pressure results in a decrease of density. (Temperature remaining constant.)

3. With an increase in temperature, pressure and/or density must change. In the free atmosphere, the temperature-increase frequently results in expansion of the air to such an extent that the decrease in density outweighs the temperature increase, and the pressure actually decreases. Likewise, the temperature increase allows an increase in moisture, which in turn decreases density (mass of moist air is less than that of dry air); couple this with expansion, and almost invariably, the final result is a decrease in pressure.

HUMIDITY

As indicated earlier, weather conditions depend greatly upon the amount of water in the air. The water may be in any of three forms—gas, liquid, or solid. As a gas, it is called water vapor, which is invisible. Solid or liquid water is visible as precipitation or as clouds.

Humidity is a comprehensive concept; therefore, there are available many different definitions and many different manners of expressing humidity.

Most of the weather that interferes with the operation of aircraft is directly associated with water in some form.

WATER VAPOR CHARACTERISTICS

Water vapor is a universal constituent of the atmosphere. Any given volume of atmosphere at a given temperature can contain only a certain maximum quantity of water vapor. The maximum amount (by volume) of water vapor that the air can hold is about 4 percent. If more and more water vapor is injected into a given container of dry air kept at a constant temperature, a point is reached when the water vapor condenses, or becomes liquid, as fog within the container or as dew on its walls. As more and more water vapor is added, more of it condenses; but the total amount of vapor in the container remains unchanged, though the amount of liquid water in the form of fog or dew increases. The volume of air in the container is then said to be saturated with water vapor.

The quantity of water vapor needed to produce saturation does not depend on the pressure of other atmospheric gases; consequently, at a given temperature, the same amount of water vapor will saturate a given volume of air whether it be on the ground at a pressure of 1000 mb or at 17,000-ft altitude with only 500 mb pressure, if the temperature is the same. Since density decreases with altitude, a given volume of air would contain less mass (grams) at 17,000 ft than at the surface; therefore, in a saturated volume, there would be more water vapor per gram of air at this altitude than at the surface.

Temperature

Although the quantity of water vapor in a saturated volume of atmosphere is independent of the air pressure, IT DOES DEPEND ON THE TEMPERATURE. The higher the temperature, the greater the tendency for liquid water to turn into vapor. At a higher temperature, therefore, more vapor must be injected into a given volume before the saturated state is reached and dew or fog forms. On the other hand, cooling a saturated volume of air forces some of the vapor to condense and the quantity of vapor in the volume to diminish.

Pressure (Dalton's Law)

The laws relative to the pressure of a mixture of gases were formulated by the English physicist, John Dalton. One of the laws states that the partial pressures of two or more mixed gases (or vapors) are the same as if each filled the space alone. The other law states that the total pressure is the sum of all the partial pressures of gases and vapors present in an enclosure.

Water vapor, in the atmosphere, for instance, is independent of the presence of other gases; the vapor pressure is independent of the pressure of the dry gases in the atmosphere, and vice versa. However, the total atmospheric pressure is found by adding all the pressures—those of the dry air and the water vapor.

TERMS

The actual amount of water vapor contained in the air is usually less than the saturation amount. The amount of water vapor in the air is expressed in several different manners. Some of the principal methods are described in the following portion of this section.

Relative Humidity

Although the major portion of the atmosphere is not saturated, for weather analysis it is desirable to be able to say how near it is to being saturated. This relationship is expressed as relative humidity. The relative humidity of a volume of air is the ratio (in percent) between the water vapor actually present and the water vapor necessary for saturation at a given temperature.

Assume, for instance, that the temperature is 25° C. The amount of water vapor needed to saturate a cubic meter of air at this temperature is 23.05 grams. If observation indicates only 11.525 grams of vapor in a cubic meter, the sample volume is half saturated, or its relative humidity is 50 percent.

Relative humidity is also defined as the ratio (expressed in percent) of the observed vapor pressure to that required for saturation at the same temperature and pressure.

Relative humidity shows the degree of saturation, but it gives no clue to the actual amount of water vapor in the air. Thus, other expressions of humidity are useful.

Absolute Humidity

The mass of water vapor present per unit volume of space, usually expressed in grams per cubic meter, is known as absolute humidity. It may be thought of as the density of the water vapor.

Specific Humidity

Humidity may be expressed as the mass of water vapor contained in a unit mass of air (dry air plus the water vapor), or as the ratio of the density of the water vapor to the density of the air (MIXTURE OF DRY AIR AND WATER VAPOR). This is called the specific humidity and is expressed in grams per gram or in grams per kilogram. Since this value depends upon the measurement of mass, and mass does not change with temperature and pressure, the specific humidity of a parcel of air remains constant unless water vapor is added to or taken from the parcel. For this reason, air which is unsaturated may move from place to place or from level to level, and its specific humidity remains the same as long as no water vapor is added or removed. However, if the air is saturated and cooled, some of the water vapor must condense; consequently, the specific humidity (which reflects only the water vapor) decreases. If saturated air is heated, its specific humidity remains unchanged unless water vapor is added to it, in which case the specific humidity increases. The maximum specific humidity which a parcel can have occurs at saturation and depends upon both the temperature and the pressure. Since warm air can hold more water vapor than cold air at constant pressure, the saturation specific humidity at high temperatures is greater than at low temperatures. Also, since moist air is less dense than dry air at constant temperature, a parcel of air has a greater specific humidity at saturation, if the pressure is low, than when the pressure is high.

Mixing Ratio

The mixing ratio is defined as the ratio of the mass of water vapor to the mass of DRY AIR and is expressed in grams per gram or in grams per kilogram. It differs from specific humidity only in that it is related to the mass of dry air instead of to the total dry air plus water vapor. It is very nearly equal numerically to specific humidity, but it is always slightly greater. The mixing ratio has the same characteristic properties as the specific humidity, in that it is conservative for atmospheric processes involving a change in temperature but is nonconservative for changes involving a gain or loss of water vapor.

Previously it was learned that air at any given temperature can hold only a certain amount of water vapor before it is saturated. The total amount of vapor which air can hold at any given temperature, by weight relationship, is referred to as the saturation mixing ratio. It is useful to note that the following relationship exists between mixing ratio, saturation mixing ratio, and relative humidity: Relative humidity is equal to the mixing ratio divided by the saturation mixing ratio, multiplied by 100. If any two of the three components in this relationship are known, the third may be determined by simple mathematics.

Dew Point

The dewpoint is the temperature to which air must be cooled, at constant pressure and constant water vapor content, in order for saturation to occur. The dewpoint is a conservative and very useful element. When atmospheric pressure stays constant, the dewpoint reflects increases and decreases in moisture in the air, and also shows at a glance, under the same conditions, how much cooling of the air is required to condense moisture from the air.

CHANGE OF STATE

A change of state (or change of phase) of a substance describes the change of a substance from a solid to a liquid, liquid to a vapor, vapor to a liquid, liquid to a solid, solid to vapor, or vapor to a solid. In meteorology we are concerned primarily with the change of state of water in the air. Water is present in the atmosphere in any or all of the three states (solid, liquid, and vapor) and changes back and forth from one state to another. The mere presence of water is important, but the change of state of the water in the air is more important because the change of state of water affects the weather directly. The solid state of water is in the form of ice crystals; the liquid state of water is in the form of raindrops, clouds, and fogs, while the vapor state of water is in the form of an unseen gas in the air. (See fig. 12-8.)

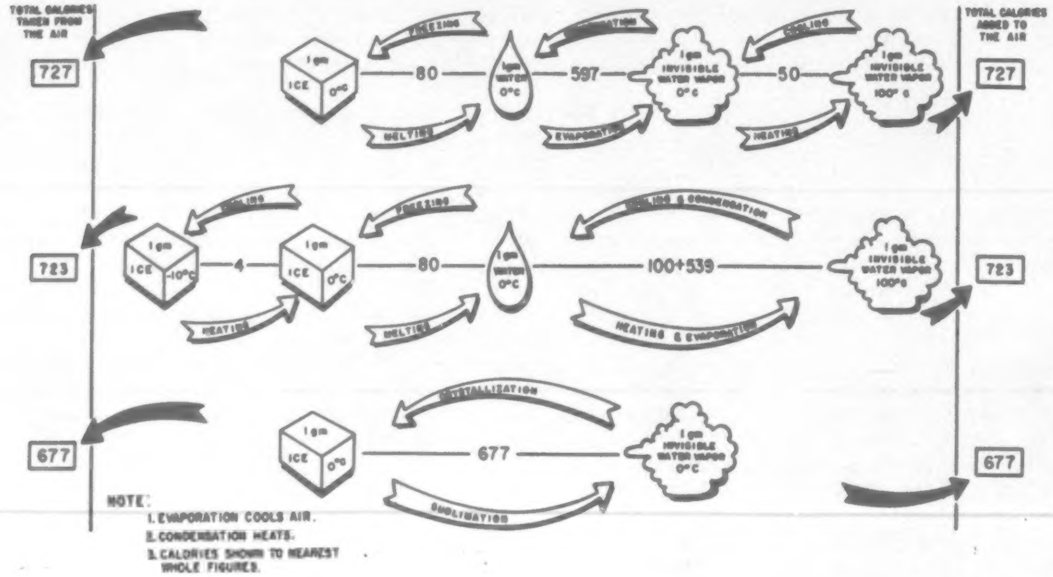
Energy is involved in the various changes of state which occur in the atmosphere. This energy is primarily in the form of heat. The heat which is used by the substance in changing its state is referred to as the latent heat and is usually stated in calories. The calorie is a unit of heat energy. It is the amount of heat required to raise the temperature of 1 gram of water 1° C. A closer look at some of the major changes of state of the atmosphere helps to clarify latent heat.

LIQUID TO SOLID AND VICE VERSA

Fusion is the change of state from a solid to a liquid at the same temperature. The number of gram calories of heat necessary to change 1 gram of a substance from the solid to the liquid state is known as the heat of fusion. To change 1 gram of ice to 1 gram of water at a constant temperature and pressure requires roughly 80 calories of heat; this is called the latent heat of fusion. The opposite of fusion is freezing—a liquid changes into a solid. Since it requires 80 calories to change 1 gram of ice to 1 gram of water, this same amount of heat is released when 1 gram of water is changed to ice.

LIQUID TO GAS AND VICE VERSA

Water undergoes the process of evaporation when changing from the liquid to gaseous state. According to the molecular theory of matter, all matter consists of molecules in motion. The molecules in a bottled liquid are restricted in their motion by the walls of the container. However, on a free surface exposed to the atmosphere, the motion of the molecules in the liquid is restricted by the weight of the atmosphere or, more precisely, by the atmospheric pressure. If the speed of the liquid molecules is sufficiently high, they escape from the surface of the liquid into the atmosphere. As the temperature of the liquid is increased, the speed of the molecules is increased, and the rate at which the molecules escape from the surface also increases. Evaporation takes place only from the free surface of a substance.


TOTAL CALORIES TAKEN FROM THE AIR
TOTAL CALORIES ADDED TO THE AIR
727
FREEZING
CONDENSATION
COOLING
1 gm ICE 0°C
80
1 gm WATER 0°C
597
1 gm INVISIBLE WATER VAPOR 0°C
50
1 gm INVISIBLE WATER VAPOR 100° C
MELTING
EVAPORATION
HEATING
727
723
COOLING
FREEZING
COOLING & CONDENSATION
1 gm ICE -10°C
4
1 gm ICE 0°C
80
1 gm WATER 0°C
100+539
1 gm INVISIBLE WATER VAPOR 100°C
HEATING
MELTING
HEATING & EVAPORATION
723
677
CRYSTALLIZATION
1 gm ICE 0°C
677
1 gm INVISIBLE WATER VAPOR 0°C
SUBLIMATION
677
NOTE:
1. EVAPORATION COOLS AIR.
2. CONDENSATION HEATS.
3. CALORIES SHOWN TO NEAREST WHOLE FIGURES.

209.12

Figure 12-8.—Thermal history of 1 gram of ice.

During the process of evaporation, heat is absorbed by the water being vaporized. The amount absorbed is approximately 539 calories per gram of water if the water is at a temperature of 100° C. On the other hand, the amount is 597.3 calories, if the evaporation takes place at a water temperature of 0° C. This energy is required to keep the molecules in the vapor state and is called the latent heat of vaporization. Since the water needs to absorb heat in order to vaporize, heat must be supplied or else evaporation cannot take place. The air provides this heat. For this reason, evaporation is said to be a cooling process, because by supplying the heat for vaporization, the temperature of the air is lowered.

Basically condensation is the opposite of evaporation, in that water vapor undergoes a change in state from gas to liquid. However, a condition of saturation must be fulfilled before condensation can occur; that is, the air must contain all the water vapor it can hold (100 percent relative humidity) before any of it can condense from the atmosphere.

In the process of condensation, the heat that was absorbed in evaporation is released from the water vapor into the air and is called the latent heat of condensation.

SOLID TO GAS AND VICE VERSA

Sublimation is the change of state from a solid to a vapor or vice versa at the same temperature. In physics and chemistry, sublimation is usually regarded only as the change of state from solid to vapor, but meteorologists do not make this distinction. The heat of sublimation equals the heat of fusion plus the heat of vaporization for a substance. The calories required for water to sublime are: 80 + 597.3 = 677.3, if the vapor has a temperature of 0° C.

The process of vapor passing directly into the solid form without going through the liquid phase is called crystallization. This process, as well as its reverse, is often called sublimation in meteorology.

The calories liberated by crystallization are the same as those for sublimation. Crystallization frequently takes place in the atmosphere when supercooled water vapor crystallizes directly into ice crystals and forms cirriform clouds.

ADIABATIC PROCESS

An adiabatic process is one in which no heat is added to or taken away from the mass of air by exchange with the environment during the process.

DESCRIPTION

If a given parcel of air is compressed adiabatically, its temperature rises, since the work of compression is converted into heat. If a given parcel of air expands adiabatically against external pressure, its temperature falls, since some of the heat energy of the air parcel is used in doing the work of pushing back its boundaries. The heating of air during compression causes a tire pump to be warmer when inflating a tire, because work is being done on the gas. The cooling of air by expansion occurs when air is allowed to escape from the tire, because the air is doing work as it expands. (See "Gas Laws.")

Remember, in an adiabatic process an increase in temperature is due only to COMPRESSION when the air sinks or subsides. A decrease in temperature is due only to EXPANSION when air rises, as in convective currents or going over mountains. There is no addition or subtraction of heat involved. The changes in temperature are due to the conversion of energy from one form to another. It should also be noted that the atmosphere has a tendency to resist vertical motion. This is known as stability. Stability can best be explained by a brief description of the ball and bowl analogy (fig. 12-9).

In this analogy a bowl is set on a flat surface with a ball placed inside it. The ball will rest in the bottom of the bowl; but, if we push the ball in any direction, it will seek out the bottom of the bowl again. This is referred to as ABSOLUTE STABILITY (fig. 12-9 (A)). Turn the bowl upside down, position the ball anywhere on the bowl's bottom surface, fig. 12-9 (B) and the ball will start moving on its own without any other force being applied. This is a condition of ABSOLUTE INSTABILITY. If we now remove the bowl and place the ball on the flat surface (fig. 12-9 (C)), we have NEUTRAL STABILITY—that is, if a force is applied to the ball, it moves; but if the force is removed, it will stop with no further movement.

Air in our atmosphere reacts in a similar manner when moved up or down. If it is moved up and becomes denser than the surrounding air, it will return to its original position and be considered STABLE. If it becomes less dense than the surrounding air, it will continue to rise and be considered UNSTABLE. When density remains the same as the surrounding air after being lifted it will be considered NEUTRALLY STABLE, having no tendency to rise or sink further.

LAPSE RATES

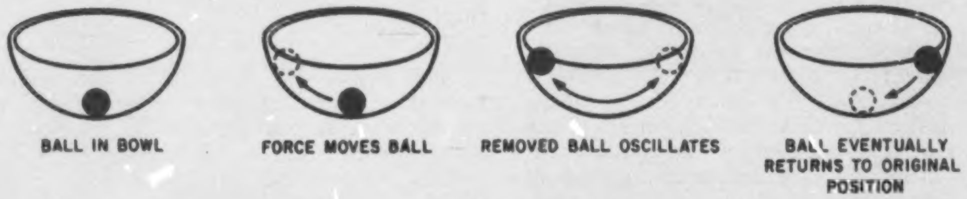
Lapse rate is a decrease in any atmospheric variable with height, but is generally applied to temperature in meteorology. (See table 12-3.)

Dry Adiabatic Lapse Rate

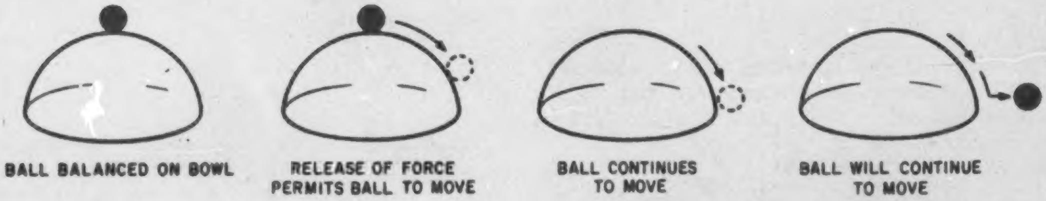
If a parcel of air is lifted, its pressure is decreased, since pressure decreases with height, and its temperature falls due to the expansion. If the air is dry and the process is adiabatic, the rate of temperature fall is 1° C per 100 meters of lift, or 5 1/2° F per 1,000 feet of lift; if the parcel descends to higher

Table 12-3.—Lapse rates of temperature

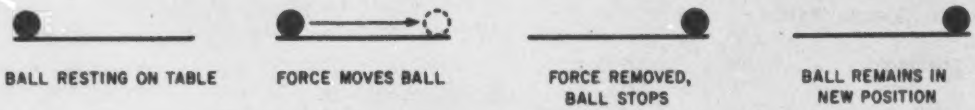
Lapse rate	Per 1,000 feet	Per 100 meters
Dry adiabatic	5 1/2° F	1° C
Saturation (moist) adiabatic	2-3° F	.55° C
Average	3.3° F	.65° C
Superadiabatic	5 1/2-15° F	1-3.42° C
Autoconvective	More than 15° F	More than 3.42° C


BALL IN BOWL
FORCE MOVES BALL
REMOVED BALL OSCILLATES
BALL EVENTUALLY RETURNS TO ORIGINAL POSITION

(A) ABSOLUTE STABILITY


BALL BALANCED ON BOWL
RELEASE OF FORCE PERMITS BALL TO MOVE
BALL CONTINUES TO MOVE
BALL WILL CONTINUE TO MOVE

(B) ABSOLUTE INSTABILITY


BALL RESTING ON TABLE
FORCE MOVES BALL
FORCE REMOVED, BALL STOPS
BALL REMAINS IN NEW POSITION

(C) NEUTRAL STABILITY

209.364

Figure 12-9.—Analogy depiction of stability.

pressure, its temperature increases at the rate of 1° C per 100 meters, or 5 1/2° F per 1,000 feet. This is known as the dry adiabatic lapse rate.

Saturation Adiabatic Lapse Rate

When a mass of air is lifted, it cools at a practically constant rate of 5 1/2° F per 1,000 feet as long as it remains unsaturated (relative humidity below 100 percent). If the original moisture is being carried along with the mass as it ascends, it cools to its saturation temperature, and the relative humidity is then 100 percent. Condensation takes place with any further cooling. For each gram of water condensed, about 597 calories of heat are liberated. This latent heat of condensation is absorbed by the air, and the adiabatic cooling rate is decreased to 2° to 3° F per 1,000 feet instead of 5 1/2° F per 1,000 feet. The process during the saturated expansion of the air is called the saturation adiabatic, the moist adiabatic, or the pseudoadiabatic process. The pseudoadiabatic process assumes that moisture falls out of the air as soon as it condenses.

How the temperature of a parcel of air changes in response to these processes can be illustrated by lifting a parcel of air over a mountain. Assume that a saturated parcel of air having a temperature of 44° F is at 5,000 feet and is forced over a 12,000-foot mountain. Condensation occurs from 5,000 to 12,000 feet so that the parcel cools at the moist adiabatic rate (3° F per 1,000 ft) and reaches a temperature of approximately 23° F at the top of the mountain. Assuming that the condensation has fallen out of the air during the ascent, the parcel heats at the dry adiabatic rate as it descends the other side of the mountain; when it reaches the 5,000-foot level, the parcel will have a temperature of approximately 61° F.

Average Adiabatic Lapse Rate

The average lapse rate lies between the dry adiabatic and the moist adiabatic at about 3.3° F per 1,000 feet.

Super Adiabatic Lapse Rate

The superadiabatic lapse rate is a decrease in temperature of more than 5 1/2° F per 1,000 feet and less than 15° F per 1,000 feet.

Autoconvective Lapse Rate

The autoconvective lapse rate is the decrease of more than 15° F per 1,000 feet. This lapse rate is rare and is usually confined to shallow layers.

MOTION

Any general discussion of the principles of physics would be incomplete without some consideration of the way in which mass, force, and motion are related. We know from experience that an object at rest never starts to move by itself; a push or a pull must be exerted on it by some other object. This external force is needed because the body has inertia.

TERMS

In dealing with motion, several terms are commonly used, which should be defined before venturing into the study of motion. They are:

Speed

The rate at which a body moves. It should not be confused with velocity. In meteorology speed is the term that is used when only rate of movement is meant.

Direction

The line along which something moves or lies. In meteorology, we may speak of direction "toward" or direction "from".

Velocity

The term velocity describes both the rate at which a body moves and the direction in which it travels.

Acceleration

This is the term applied to the time-rate of change of velocity. In relation to Newton's Second Law of motion the following statements are derived.

1. For different forces acting upon the same mass, different accelerations are produced that are proportional to the forces.

2. For different masses to acquire equal acceleration by different forces, the forces must be proportional to the masses.

3. Equal forces acting upon different masses produce different accelerations that are proportional to the masses.

LAWS OF MOTION

The atmosphere, it is found, is constantly in motion. This motion does not just happen of its own accord; there are forces at work which cause it to move. Some forces cause it to move from one elevation, or height, to another as convective currents. Other factors cause it to move in various directions with a great range of speed. Still other factors cause it to move in either a clockwise or counterclockwise fashion over wide areas. Perhaps a review of Newton's laws of motion will aid the Aerographer's Mate in understanding some of the reasons why the atmosphere moves as it does.

Sir Isaac Newton, a foremost English physicist, formulated three important laws relative to motion. In his first law, the law of inertia, he stated that every body continues in its state of rest and uniform motion in a straight line unless it is compelled to change by applied forces. Although the atmosphere is a mixture of gases and has the properties peculiar to gases, it still behaves in many respects as a body when considered in the terms of Newton's law. There would be no movement of great quantities of air unless there was a force to cause it. For instance, air moves from one area to another because there is a force (or forces) great enough to change its direction or to overcome its tendency to remain at rest.

The second of Newton's laws of motion, force and acceleration, states that change of motion of a body is proportional to the applied force and takes place in the direction of the straight line in which that force is applied. In respect to the atmosphere, this means that the change of the motion of the atmosphere is determined by the force acting upon it, and takes place in the direction of that force.

Newton's third law of motion, reacting forces, states that to every action there is always an equal and opposite reaction, or the mutual actions of two bodies are always equal and oppositely directed. Consequently, there is never a force acting in nature unless there are two bodies, one impressing, or exerting, the force and the other being impressed by force. Still another aspect of the law is that a force cannot exist by itself; it must exist along with another force. It is clear, then, that there must be at least two bodies and two forces. In the atmosphere there are many masses, or bodies, of air, each exerting a force and having a force exerted against it. This association of mass and force results in work, and work is energy.

Energy is defined as the ability to do work. Energy is also something that produces changes in matter. Heat can change water from a liquid to a gas, for example. There are many different kinds of energy, but we are mainly concerned with those kinds which affect the processes in the atmosphere. The energy principle simply stated is that energy is measured by the amount of work a body can do. Work is done only when a force succeeds in moving the body it acts upon. The quantity of work done is equal to the product of the force times the distance moved. Therefore, we derive the formula

$$W = Fd$$

where W is the amount of work done, F is the force, and d is the distance.

Work is measured in the English system by the foot-pound; that is, if 1 pound of force acts through a distance of 1 foot, it performs 1 foot-pound of work. In the metric CGS system, if the force is measured in dynes, the distance is measured in centimeters, and the work is denoted in ergs (an erg is the work done by a force of one dyne exerted for a distance of one centimeter). Another unit used to measure work is the joule. It is simply 10,000,000 ergs, and is equivalent to just under three-fourths of a foot-pound.

Two kinds of energy are important in our study of atmospheric physics. They are potential energy (or energy at rest or of position) and kinetic energy (or the energy of motion).

BALANCE OF FORCES—WIND

Newton's first two laws of motion indicate that motion tends to be in straight lines and only deviates from such lines when acted upon by another force, or by a combination of forces. The air tends, for instance, to move in a straight line from a high-pressure area to a low-pressure area. However, there are forces which prevent the air from moving in a straight line.

Pressure Gradient Force

The variation of heating (and consequently the variations of pressure) from one locality to another is the initial factor that produces movement of air, or wind. The most direct path from high to low pressure is one along which the pressure is changing most rapidly; the rate of change is called the pressure gradient. Pressure gradient force is the force that moves air from an area of high pressure to an area of low pressure. The velocity of the wind depends upon the pressure gradient. If the pressure gradient is steep, the wind speed is strong; if the pressure gradient is weak, the wind speed is light.

Coriolis Effect

If pressure gradient force were the only force affecting windflow, the wind would blow at right angles across isobars (lines connecting points of equal barometric pressure) from high to low pressure. From observation we know the wind actually blows parallel to isobars above any frictional level. Therefore, other factors must be affecting the windflow, and one of these factors is the rotation of the earth. A particle at rest on the earth's surface is in equilibrium. If the particle starts to move because of a pressure gradient force, its relative motion is affected by the rotation of the earth. If a mass of air from the Equator moves northward, it is deflected to the right, so that a south wind tends to become a southwesterly wind.

An air mass moving from the North Pole tends to become a northeasterly wind. This deflection is known as the Coriolis effect and is stated as a law. (See fig. 12-10.) This law states that when a mass of air starts to move over the earth's surface, it is deflected to the right of its path in the Northern Hemisphere and to the left of its path in the Southern Hemisphere. Coriolis effect is dependent upon the latitude and speed of the moving air mass. It is greatest at the poles and nonexistent at the Equator. It increases as the speed of the moving air mass increases.

Centrifugal Effect

According to Newton's first law of motion, a body in motion continues in the same direction in a straight line and with the same speed unless acted upon by some external force. Therefore, for a body to move in a curved path, some force must be continually applied. The force restraining bodies to move in a curved path is called the centripetal force, and it is always directed toward the center of rotation. When a rock is whirled around on a string, the centripetal force is afforded by the tension of the string.

Newton's third law states that for every action there is an equal and opposite reaction. Centrifugal force is the reacting force which is equal to and opposite in direction to the centripetal force. Centrifugal force, then, is a force directed outward from the center of rotation.

As you know, a bucket of water can be swung over your head at a rate such that the water does not come out. This is an example of both centrifugal and centripetal force. The water is being held in the bucket by centrifugal force tending to pull it outward. The centripetal force, the force holding the bucket and water to the center, is your arm swinging the bucket. As soon as you cease swinging the bucket, the forces cease, and the water falls out of the bucket. Figure 12-11 is a simplified illustration of centripetal and centrifugal force.

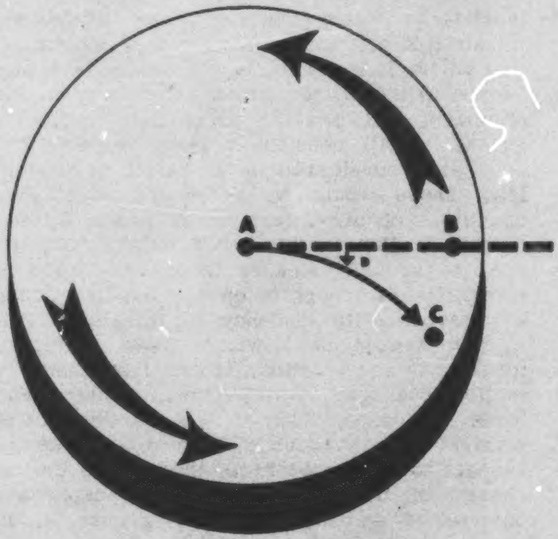


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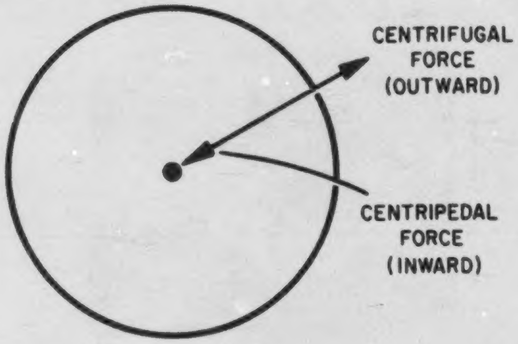
Figure 12-10.—Coriolis effect.

High- and low-pressure systems can be compared to rotating discs. Centrifugal effect tends to fling air out from the center of rotation of these systems. Therefore, when winds tend to blow in a circular path, centrifugal effect (in addition to pressure gradient and Coriolis effects) influences these winds.

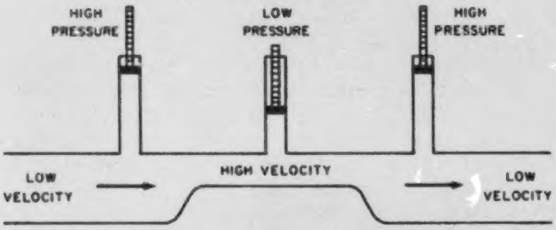
BERNOULLI'S THEOREM

According to Bernoulli's theorem, pressures are least where velocities are greatest, and pressures are greatest where velocities are least. This is true of liquids and gases. (See fig. 12-12.)

One of the practical uses of the theorem as applied to meteorology is for forecasting winds



209.10
Figure 12-11.—Simplified illustration of centripetal and centrifugal force.



209.11
Figure 12-12.—Example of Bernoulli's theorem.

of a certain kind. For the purpose of illustration, the Santa Ana wind is used. The condition which produces this wind is a high-pressure area with a strong pressure gradient situated near Salt Lake City, Utah. This gradient directs the windflow into a valley leading to the town of Santa Ana near the coast of California. As the wind enters the valley, its flow is sharply restricted by the funneling effect of the mountain sides. This restriction causes the wind speed to increase, bringing about a drop in pressure in and near the valley. This pressure drop in and near a valley, caused by the Bernoulli effect, is a valuable forecasting aid in predicting this type of wind.

OPTICAL PHENOMENA

Light sent out by such bodies as the sun or the stars or from artificial sources such as lamps and even the light reflected by the objects which it strikes, affect the eye and produce the sensation of vision. Too, much of the world's work and much of our recreation are made possible by the use of light.

Light, too, when acting in conjunction with some of the elements of the atmosphere produces such atmospheric phenomena as halos, coronas, mirages, and rainbows.

In this section of the chapter we will discuss some of the theories of light, even though scientists do not yet have a complete explanation of the nature of light, its properties, what happens to these light rays after they leave their source, and some of the atmospheric phenomena produced by light.

LIGHT

Light is the portion of the electromagnetic spectrum that can be detected by the human eye. It travels at the same speed as all other electromagnetic radiation (186,000 miles per second). However, the characteristics of light are considerably different from other regions of the electromagnetic spectrum because of the differences in wavelength and, consequently, in frequency.

Sources of Light

There are considered to be two sources of light—the natural light, nearly all of which we receive from the sun, and artificial light, such as light from electric lamps, the light of a fire, or the light from fluorescent tubes produced by the action of ultraviolet light on chemicals enclosed in the tube.

Luminous bodies are those bodies which produce their own light. We think of the sun and the stars as luminous bodies. Illuminated or nonluminous bodies are those bodies which merely reflect the light they receive and are therefore visible because of this reflection.

Theory

When light is emitted from a source, waves of radiation travel in straight lines and in all directions. A simple example of motion similar to these radiation waves can be made by dropping a pebble into a pool of water. The waves spread out in expanding circles. Actually, light waves spreading in all directions form a sphere instead of a simple circle. The boundary formed by each wave is called a "wave front."

Lines drawn from the light source to any point on one of these waves indicate the direction in which the wave fronts are moving. These lines are the radii of the spheres formed by the wave fronts and are called light rays.

Light radiates from its source in all directions until absorbed or diverted by coming in contact with some substance.

Wavelength

Wavelength means the distance from the crest of one wave to the crest of the following wave, or the distance from one corresponding point on one wave to a corresponding point on the next wave. Wavelength, frequency (the number of waves which pass a given point in a unit of time), and speed are related by the simple equation:

$$C = \lambda F$$

Where:

C = speed
λ = wavelength
F = frequency

Since the speed of electromagnetic energy is constant, the frequency must increase if the wavelength decreases and vice versa.

Wavelengths are measured in ANGSTROM UNITS, or more usually, an Angstrom (Å). They may also be measured in millimicrons which are millionths of millimeters; the symbol is mμ. In figures 12-13 and 12-14 we can see the visible and invisible spectrum's colors in relation to their wavelengths. Figure 12-14 shows the visible spectrum of wavelengths only occupies a very small portion of the complete electromagnetic spectrum and that it only extends between 4,000 and 7,000 angstroms.

Characteristics

When light waves encounter any substance, they are either transmitted, reflected, or absorbed. (See fig. 12-15.)

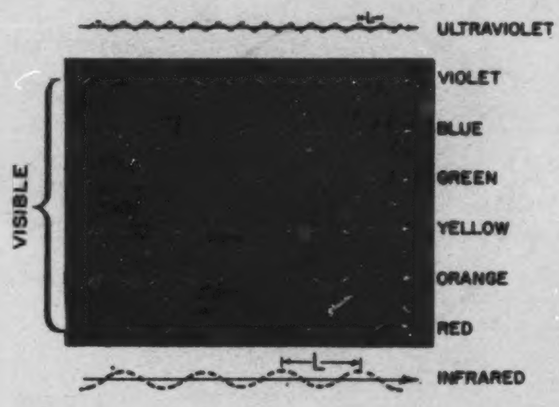


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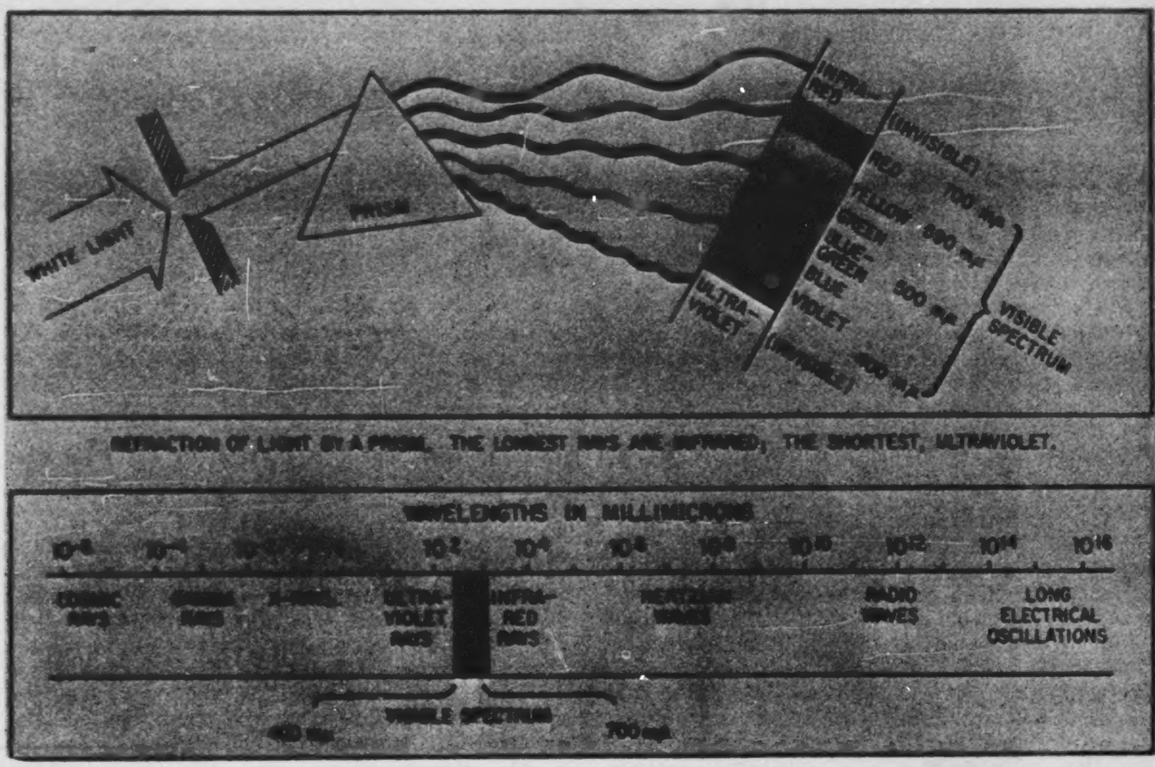
Figure 12-13.—Wavelength of various visible and invisible colors.

Those substances which permit the penetration of clear vision through them, and which transmit almost all the light falling upon them are said to be transparent; air and glass are examples. There is no substance known which is perfectly transparent, but many substances are nearly so. Those substances which allow the passage of part of the light but appear clouded and impair vision substantially, are called translucent; frosted electric lamps and parchment shades are examples. Those substances which do not transmit any light are called opaque.

All objects which are not light sources are visible only because they reflect all or some part of the light reaching them from some luminous source. If light is neither transmitted nor reflected, it is absorbed or taken up by the medium. When light strikes a substance, some absorption and reflection always take place. No substance completely transmits, reflects, or absorbs all the light which reaches its surface. Figure 12-15 shows how glass transmits, absorbs, and reflects light.

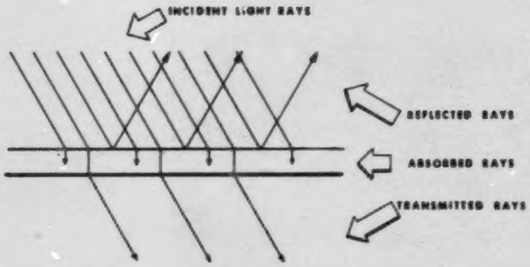
Candlepower and Foot-Candles

Illumination is the light received from a light source. The intensity of illumination is measured in foot-candles. A foot-candle is the amount of light falling upon a surface 1 square foot in area, 1 foot away from the light source of 1 candle-power.


WHITE LIGHT
PRISM
INFRA-RED
(INVISIBLE)
RED 700 mμ
YELLOW 590 mμ
GREEN
BLUE-GREEN
BLUE 500 mμ
VIOLET
400 mμ
(INVISIBLE)
ULTRA-VIOLET
VISIBLE SPECTRUM
REFRACTION OF LIGHT BY A PRISM. THE LONGEST RAYS ARE INFRARED; THE SHORTEST, ULTRAVIOLET.
WAVELENGTHS IN MILLIMICRONS
10⁻⁶
10⁻⁴
10²
10⁴
10⁶
10⁸
10¹⁰
10¹²
10¹⁴
10¹⁶
COSMIC RAYS
GAMMA RAYS
X-RAYS
ULTRA-VIOLET RAYS
INFRA-RED RAYS
HERTZIAN WAVES
RADIO WAVES
LONG ELECTRICAL OSCILLATIONS
VISIBLE SPECTRUM
400 mμ
700 mμ

209.14

Figure 12-14.—Wavelengths and refraction.


INCIDENT LIGHT RAYS
REFLECTED RAYS
ABSORBED RAYS
TRANSMITTED RAYS

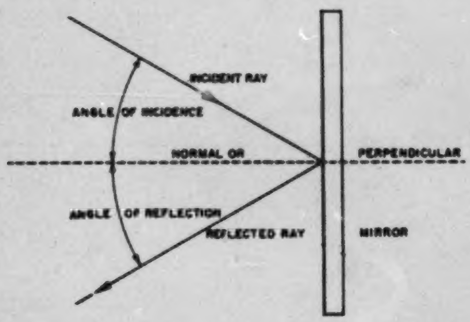
209.15

Figure 12-15.—Light rays reflected, absorbed, and transmitted.

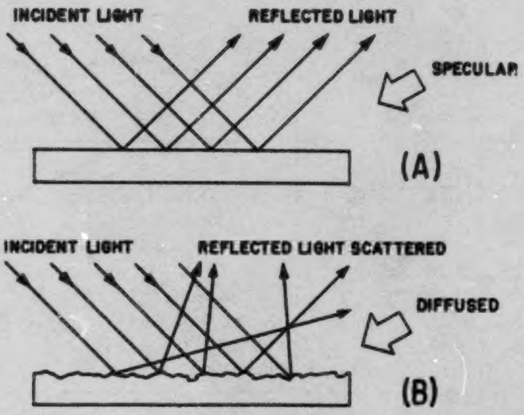
REFLECTION

The term "reflected light" simply refers to those light waves that are neither transmitted nor absorbed, but are thrown back from the surface of the medium they encounter. If a ray of light is directed against a mirror, the light ray that strikes the surface is called the incident ray, and the one that bounces off is the reflected ray. The imaginary line perpendicular to the mirror at the point where the ray strikes is the NORMAL. The angle between the incident ray and the normal is the angle of incidence. The angle between the reflected ray and the normal is the angle of reflection. These terms are illustrated in figure 12-16.

If the surface of the medium contacted by the incident light ray is smooth and polished, such as a mirror, the reflected light will be thrown back at the same angle to the surface


INCIDENT RAY
ANGLE OF INCIDENCE
NORMAL OR
PERPENDICULAR
ANGLE OF REFLECTION
REFLECTED RAY
MIRROR

209.17
Figure 12-16. — Terms used to describe the reflection of light.


INCIDENT LIGHT
REFLECTED LIGHT
SPECULAR
(A)
INCIDENT LIGHT
REFLECTED LIGHT SCATTERED
DIFFUSED
(B)

209.18
Figure 12-17. — Reflected light. (A) Regular (specular); (B) irregular (diffused).

as the incident light. The path of the light reflected from the surface forms an angle exactly equal to the one formed by its path in reaching the medium. This conforms to the law of reflection which states: The angle of incidence is equal to the angle of reflection.

Reflection from a smooth-surfaced object presents few problems. It is a different matter, however, when a rough surface reflects light. The law of reflection still holds; but because the surface is rough, the angle of incidence will be different for each ray of light. The reflected light will be scattered in all directions as shown in figure 12-17.

This form of reflected light is called irregular or diffused light.

REFRACTION

The change of direction which occurs when a ray of light passes at an oblique angle (less than 90°) from one transparent substance into another of different density is called refraction.

Refraction is due to the fact that light travels at various speeds in different transparent substances; that is, substances of different density. It travels faster in less dense substances.

Refraction, or change of direction, always follows a simple rule. When the light ray passes from one transparent substance into another of greater density, refraction is toward the normal. (In this rule, the normal means a line perpendicular to the surface of the medium at the point of entrance of the light ray.) In passing from one transparent substance into another of lesser density, refraction is away from the normal.

Consider a ray of light entering a denser medium at an angle of 90° (perpendicular), such as from air to water as illustrated in figure 12-18. The speed of the wave fronts slows down as the wave fronts enter the denser medium (water) but they remain parallel.

AIR
DIRECTION OF LIGHT RAY

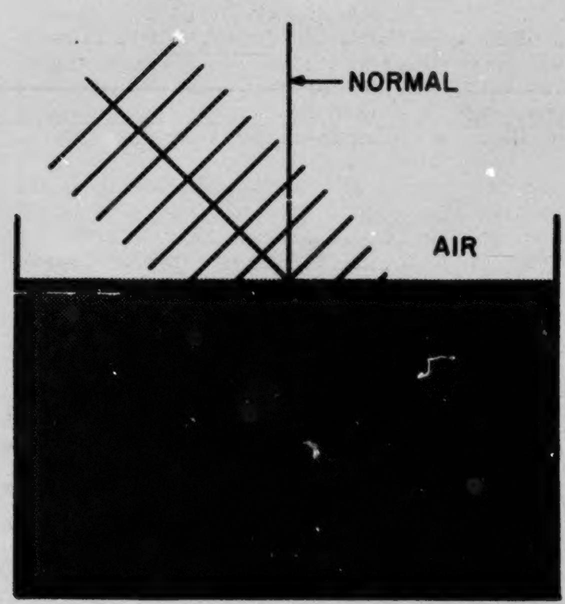
209.19
Figure 12-18.—Wave front diagram illustrating the difference in the speed of light in air and water.

Now consider this same light ray entering a denser medium at an oblique angle. That portion of the wave front which first enters the water moves slower than the other part of the wave front which is still in the air; consequently, the ray will bend. (See fig. 12-19.) Notice that the light ray bends toward the normal.

If the light ray entered a LESS dense medium at an oblique angle, the ray would bend away from the normal as illustrated in figure 12-20. The portion of a wave front which enters the less dense substance travels faster than the other part of the wave front; consequently, the ray bends away from the normal.

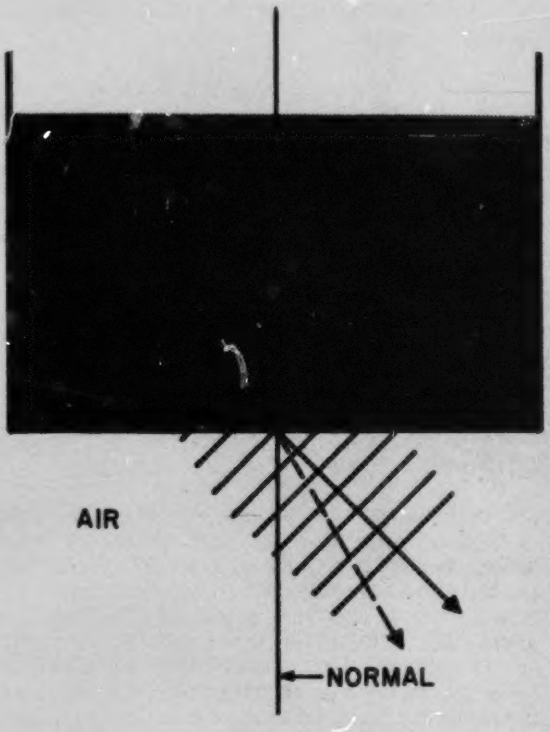
When a beam of white light is passed through a prism, as shown in figure 12-14, it is refracted and dispersed into its component wavelengths. Each of these wavelengths reacts differently on the eye which then sees the various colors that compose the visible spectrum.

The visible spectrum is recorded as a mixture of red, orange, yellow, green, blue-green, blue, indigo, and violet (fig. 12-14). Some texts may list only the six simple colors of red, orange, yellow, green, blue, and violet.



209.20

Figure 12-19.—Wave front diagram illustrating refraction of light at an air-water boundary. Ray is entering a more dense substance.



209.21

Figure 12-20.—Wave front diagram illustrating refraction of light at an air-water boundary. Ray is entering a less dense substance.

ATMOSPHERIC OPTICAL PHENOMENA

We think of atmospheric optical phenomena as those phenomena of the atmosphere which can be explained in terms of optical laws. Given below is a description of some of the optical phenomena which we commonly observe. Some of the atmospheric elements, such as moisture, serve as a prism to break a light source down into its various component colors.

Mirages

A mirage is an optical illusion due to the refraction of light as it passes through nonhomogeneous layers of the atmosphere. Distant objects are seen in an unnatural position, sometimes elevated, sometimes depressed, and often inverted; this phenomenon occurs most in hot climates over surfaces that are warmed by insolation, such as sandy plains.

Mirages may occur in any region, even on a city street. They are generally of three types: the inferior mirage, the superior mirage, and the lateral mirage. These depend, respectively, on whether the spurious image appears below, above, or to one side of the true position of the object. The inferior mirage is the most common and is responsible for the illusion of a body of water in a desert or for the illusion of a wet highway on a hot summer day. The superior mirage, more spectacular but less frequent, causes distant objects, trees, ships, mountains, etc., to appear inverted in the sky. Multiple or complex mirages have been observed.

Crepuscular Rays

These rays are beams of light apparently diverging from the sun, seen both before and after sunrise and sunset, especially in a hazy or humid atmosphere. The beams are rendered luminous by dust or water vapor. They are especially striking when they shine through rifts in the clouds. They are actually parallel, and their apparent divergency is a result of perspective.

Halos, Coronas, Rainbows, Fogbows

These are also optical phenomena; however, since they are discussed in the next chapter under photometeors, we will omit discussion of them at this time.

Cloud Iridescence

Cloud iridescence is actually nothing more than a portion of coronas. It is caused by the diffraction of light from the sun or moon. When light waves encounter an obstruction which is small in comparison with their wavelength, the light waves spread out and produce spectral colors due to interference; this is diffraction.

PROPERTIES OF SOUND

Sound as related to meteorology and oceanography has become of increasing importance to the Aerographer's Mate; consequently, it is necessary that he become familiar with some of the fundamental concepts concerning the properties of sound.

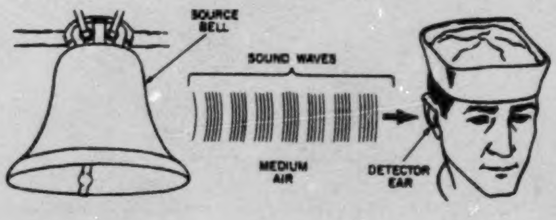
WHAT SOUND IS

Sound is the physical cause of your sensation of hearing. Anything that you hear is a sound.

Sound travels in the form of waves, which vary in length according to their frequency. A complete wavelength is called a cycle, and the number of cycles per second is the sound's frequency. Frequencies are measured in the Hertz system, 1 hertz (Hz) being equal to 1 cycle per second. Frequencies of 1000 cps or more are measured in kilohertz (kHz). Normally, sounds below 20 Hz or above 15 kHz are beyond the human hearing range. Between these two frequencies is the average human audible range. More information of the characteristics of sound is given later in this chapter.

Before sound can be produced, three basic elements must be present. (See fig. 12-21.) These elements are a source of sound, a medium to transmit the sound, and a detector to hear it. If there is no source to generate a noise, then there can be no sound. The same theory holds true for the other required elements.

You may recall the experiment in which a bell was placed inside a jar containing a vacuum. You could see the bell ringing, but you could hear nothing because there was no medium to transmit sound from the bell to you. What about the third element, the detector? You may see a source (such as an explosion) apparently producing a sound, and you know the medium (air) is present, but you are too far away to hear the noise. So far as you are concerned, there was no detector and, therefore, no sound.



209.22
Figure 12-21.— The three elements of sound.

Source

Any object that moves rapidly to and fro, or vibrates and thus disturbs the medium around it, may become a sound source. Bells, radio loudspeaker diaphragms, and stringed instruments are familiar sound sources.

Medium

Sound waves are passed along by particles of the material through which they travel. The elasticity of the medium determines the ease, distance, and speed of sound transmission. The greater the elasticity, the greater the speed of sound. The speed of sound in water is about four times that in air, for example; in steel, it is about 15 times greater than in air.

Detector

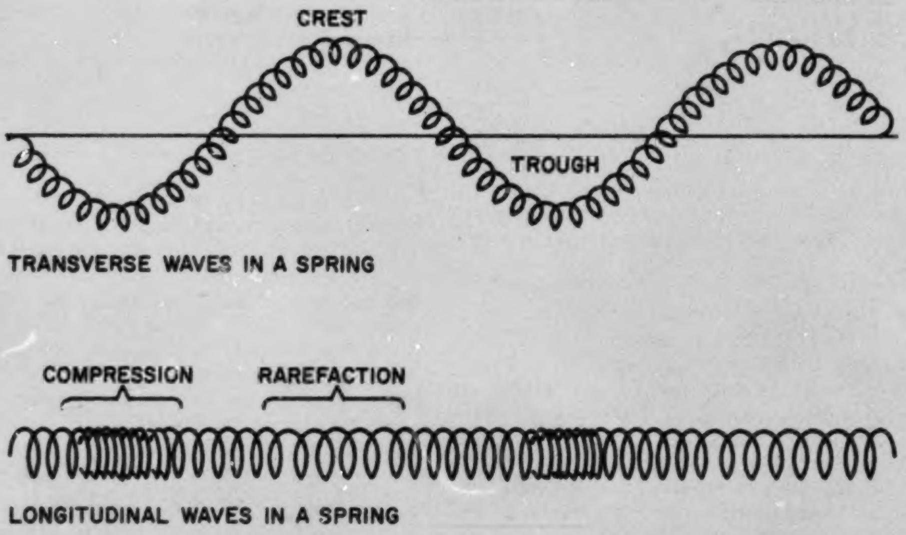
The detector acts as the receiver of the sound wave. Because it does not surround the source of the sound wave, the detector absorbs only part of the wave's energy, thereby usually requiring an amplifier to boost the signal's energy to permit reception of weak signals.

WAVES

Waves may be classified by types as transverse and longitudinal. A transverse wave is one wherein the particles of the medium through which the wave is passing move at right angles to the wave's direction. In a longitudinal wave, the particles move back and forth along the wave's direction of travel, resulting in compression and rarefaction of the wave. An example of a transverse wave is a water wave. An example of a longitudinal wave is a sound wave. Both types can be illustrated with a spring as shown in figure 12-22.

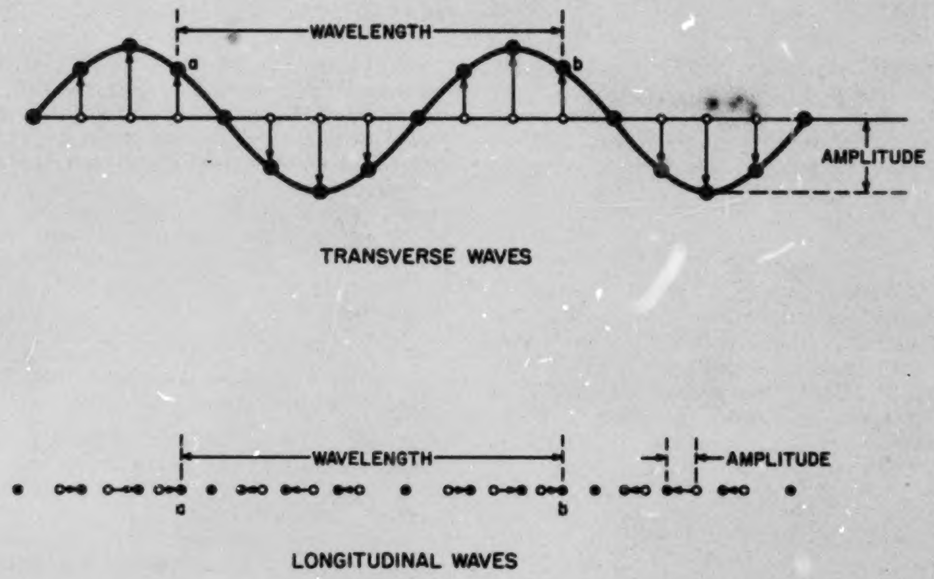
Characteristics of transverse and longitudinal waves are illustrated in figure 12-23.

In the figure, the circles show the equilibrium positions of the particles in the medium; the dots show their displaced positions; the arrows indicate the displacement of the particles from their equilibrium positions. Note that in the transverse wave, the particles move at right angles to the direction of wave movement; in the longitudinal wave, the particles move parallel to the direction of wave movement. Wavelength, which was defined earlier in the chapter, is illustrated by the distance between positions a and b. Amplitude, which is



209.23

Figure 12-22.—Comparison of transverse and longitudinal waves.



TRANSVERSE WAVES

LONGITUDINAL WAVES

209.24

Figure 12-23.—Characteristics of transverse and longitudinal waves.

the maximum displacement of the particles, is labeled on each type wave; in the transverse wave, it is half the distance measured vertically from crest to trough. Amplitude is determined by the energy of the wave.

SOUND WAVES

Sound waves are longitudinal or compression waves, set up by some vibrating object. In its forward movement, the vibrating object pushes the water particles lying against it, producing an area of high pressure, or compression.

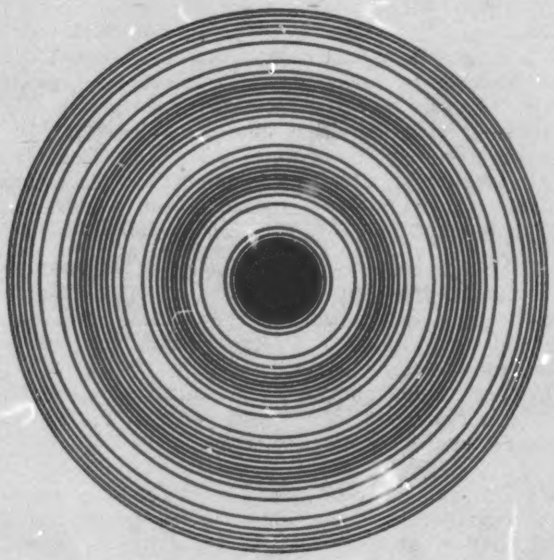
On the backward movement of the vibrating object the water particles return to the area from which they were displaced during compression and travel beyond, producing an area of low pressure, or a rarefaction. The compression moves outward by pushing the water particles immediately in front of the compressed particles. The rarefaction follows the compression, transferring the pull produced by the backward movement to the particles immediately ahead. The next forward movement of the vibrating object produces another compression and so on. In figure 12-24, the compressions are represented by dark rings. As the sound waves spread out, their energy simultaneously spreads through an increasingly large area. Thus the wave energy per unit area becomes weaker as distance increases. This loss of energy due to distance is called spreading loss.

Frequency

The frequency of a sound wave is the number of vibrations per second produced by the sound source. A source, for example, may transmit on a frequency of 5 kHz, or 5,000 vibrations per second. Motion is imparted to the sound wave by the back-and-forth movement of the particles of the medium, in effect passing the wave along, although the particles themselves have very little actual movement. The wave, however, may travel great distances at a high rate of speed.

Density

Earlier in this chapter, density has been defined as mass per unit volume, and its effect on the transmission of light has been explained.



209.25

Figure 12-24.—Sound wave travel.

Density is also an indication of the sound transmission characteristics of a substance, or medium. When a sound wave passes through a medium, it is transmitted from particle to particle. If the particles are loosely packed (as they are in fresh water as compared with sea water), they have a greater distance to move to transmit the sound energy. In so doing time is consumed, and the overall result is a slower speed of sound in a less dense medium.

Density and elasticity are the basic factors that determine sound velocity in a substance. Variations in the basic velocity of sound in the sea are caused by changes in water temperature, pressure, and density, as will be seen in chapter 16 of this manual. In fresh water of 65° F, sound velocity is approximately 4,790 feet per second (fps). In sea water, velocity depends on pressure and temperature in addition to salinity. For all practical purposes, you can assume that sound travels at a speed of 4,800 fps in sea water of 39° F.

Wavelength

Wavelength for any sound wave train is the distance between any two sucessive compressions or rarefactions. Wavelength can be computed by using the formula for wavelength previously mentioned in the section on optical phenomena. Wavelength is also dependent on frequency; therefore, when the frequency is low, the sound waves will be long; when it is high, the waves will be short.

CHARACTERISTICS OF SOUND

Basic characteristics of sound are speed, frequency, wavelength, pitch, and intensity. The first three of these characteristics have been discussed previously in this chapter.

Pitch

Pitch depends on the frequency, or number of cycles per second, which the detector receives.

An object that vibrates many times per second produces a sound with a high pitch, as in the instance of a whistle. The slower vibrations of the heavier wires within a piano cause a low-pitched sound.

Intensity

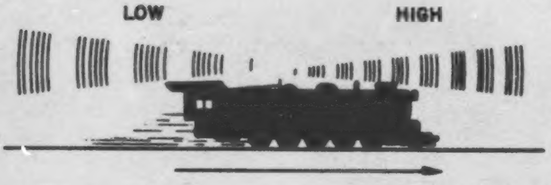
Intensity and loudness often are mistaken as having the same meaning. Although they are related, they actually are not the same. Intensity is a measure of a sound's energy. Loudness is the effect of intensity on an individual, in the same manner that pitch is the effect of frequency. Increasing the intensity causes an increase in loudness, but not in a direct proportion. To double the loudness of a sound requires about a tenfold increase in the sound's intensity. The unit of measure of sound intensity is the decibel (db), which is a measure of the intensity of a sound compared with an established standard. The intensity levels of some common noises are: a whisper, 10 to 20 db; heavy street traffic, 70 to 80 db; thunder, 110 db.

Doppler

You probably are familiar with the changing pitch of a train whistle as the train passes near you at high speed. As the train approaches, the whistle has a high frequency. As the train goes by, the frequency drops abruptly and becomes a long, drawn-out sound. The apparent change in frequency of a signal resulting from relative motion between the source and the receiver is known as doppler effect. Figure 12-25 illustrates doppler effect.

Each sound wave produced by the whistle is given an extra "push" by the motion of the train. As the train comes toward you, the resultant effect is an increase in pitch, caused by compression of the waves. As the train moves away from you, the sound waves are spread further apart, resulting in a lower pitch.

Because doppler effect varies inversely with the velocity of sound, the effect is much less marked in the sea than it is in the air.



209.26

Figure 12-25.—Doppler effect.

APPLICATION OF SOUND IN SONAR OPERATION

One of the primary applications of knowledge of sound characteristics is in SONAR operations. SONAR is an acronym for Sound Navigation and Ranging. Sound is used in SONAR operations in one of two basic ways: active ranging and passive ranging.

In passive sonar operations, sound generated by a submarine target is detected and evaluated by an antisubmarine unit, such as a destroyer. By applying the doppler principle, a sonar operator can determine if the submarine is closing or moving away from the destroyer.

In active operation the destroyer sends out a package of sound waves (pulses), which will reflect or bounce from the submarine. By knowing the direction the sound travels, the sonarman can determine the target bearing. A measure of the time required for the sound pulse to reach the target and return gives an indication of the range to the submarine.

To effectively use SONAR for submarine detection, the sonar operator must make maximum use of the various properties of sound discussed previously. Any sound the sonar detector hears that is not part of the sound package from the target is interference. The major source of interference in sonar operations is background noise.

Background noise is generated by various sources and is classified by the general type of source. Ambient noise is the noise that would be present in the sea if neither the submarine nor the destroyer were present. Ambient noise includes sea surface noise caused by agitation of the sea surface. Noise is created as water falls from the crest of a wave back to the sea surface. The intensity of sea surface noise increases as wave height increases. Another type of ambient noise is biological noise created by marine life. Biological noise varies in frequency from the high pitched sounds of the porpoise to the low-frequency noise caused by repeated clicking of claws in a shrimp bed.

In addition to ambient noise, background noise includes self noise. Self noise is noise created by the ship on which the detector is mounted. The flow of water along the hull of a moving destroyer creates noise which interferes with evaluation of the target signal. A new ship with solid seams and tight bolts and rivets would generate less self noise than an older ship.

CHAPTER 13

CIRCULATION OF THE ATMOSPHERE

For an understanding of large-scale motions of the atmosphere, it is essential that the Aerographer's Mate study the primary or general circulation of the atmosphere as a whole.

The sun's radiation is the energy that sets the atmosphere in motion, both horizontally and vertically. The vertical motion is caused by the rising and expanding of the air when it is warmed, or the descending and contracting of the air when it is cooled. The horizontal motion is caused by differences of atmospheric pressure; air moves from areas of high pressure toward areas of low pressure. Differences of temperature, the cause of the pressure differences, are due to the unequal absorption of the sun's radiation by the earth's surface. Due to the relative position of the earth with respect to the sun, much more radiation is absorbed near the Equator than at other areas, with the least radiation being absorbed at or near the poles. Consequently, the principal factor affecting the atmosphere is incoming solar radiation, and its distribution depends on the latitude and the season.

The differences in the type of surface; the differential heating; the unequal distribution of land and water; the relative position of oceans to land, forests to mountains, lakes to surrounding land, and the like, cause different types of circulations of the air.

First, there is the general or primary circulation of the atmosphere. This explains the circulation of the atmosphere as a whole with little attention to details and minor differences from time to time or place to place.

Then, there are the secondary circulations. These explain the various adjustments the primary circulation makes to major differences in heating which result from the distribution of land and sea on a large, but not a global, scale.

Finally, there are the various tertiary (third order) circulations, which explain the adjustments of the primary and secondary circulations to strictly local differences in heating.

GENERAL CIRCULATION

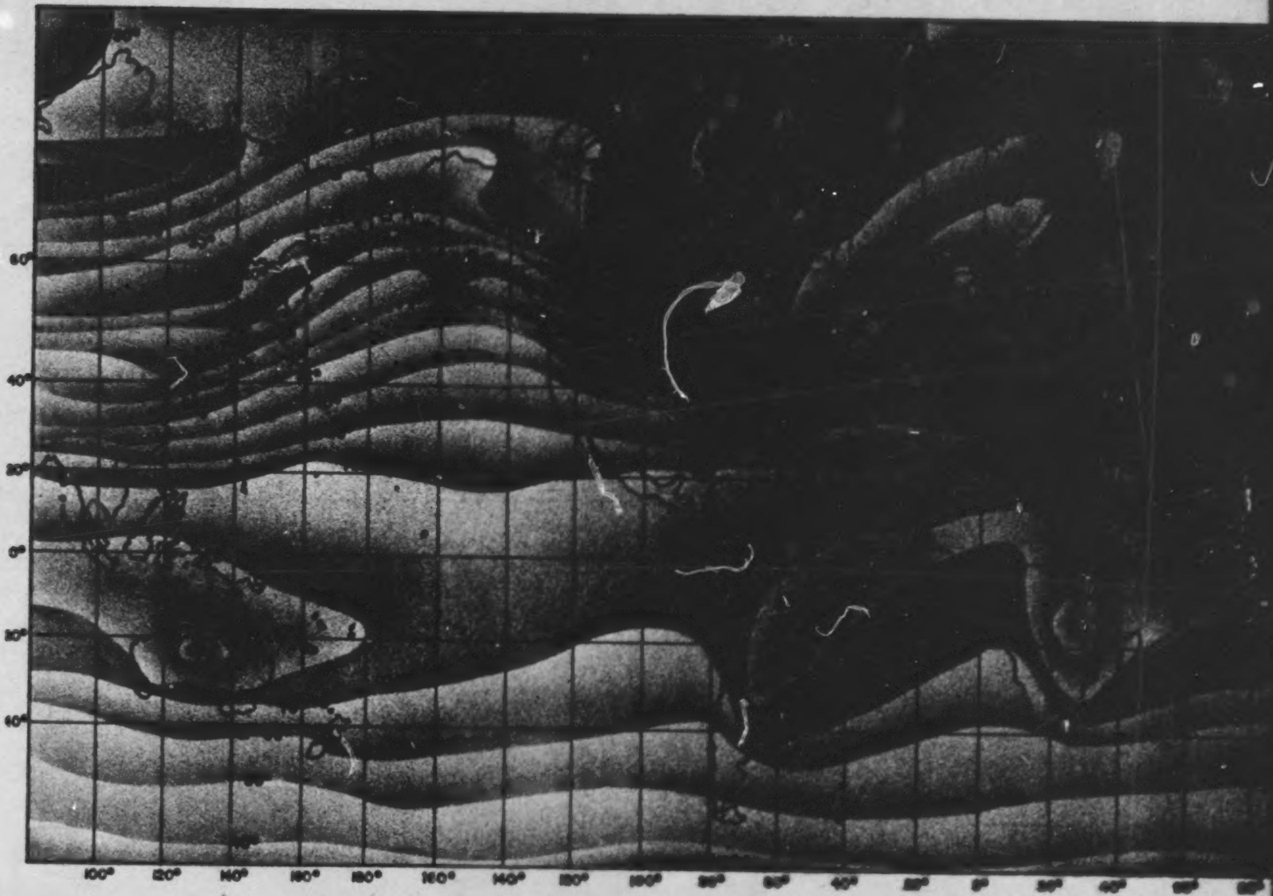
The general circulation theory attempts to explain the global circulation of the atmosphere with some minor exceptions. Since the earth heats unequally, the heat is carried away from the hot area to a cooler one as a result of the operation of physical laws. This global movement of air which restores a balance of heat on the earth is the general circulation. Since heat is the first cause, the world temperature distribution is discussed first.

WORLD TEMPERATURE GRADIENT

Temperature gradient is the rate of change of temperature with distance in any given direction at any point. World temperature gradient refers to the change in temperature that exists in the atmosphere from the Equator to the poles.

The change in temperature, or temperature differential, which causes atmospheric circulation can be compared to the temperature differences produced in a pan of water placed over a gas burner. As the water is heated, it expands and its density is lowered. This reduction in density causes the water to rise to the top of the pan. As it rises, it cools and proceeds to the edges of the pan. It cools further and sinks to the bottom, eventually working its way back to the center of the pan where it started. This process sets up a simple circulation pattern due to successive heating and cooling.

Ideally, the air within the troposphere may be compared to the water in the pan. The most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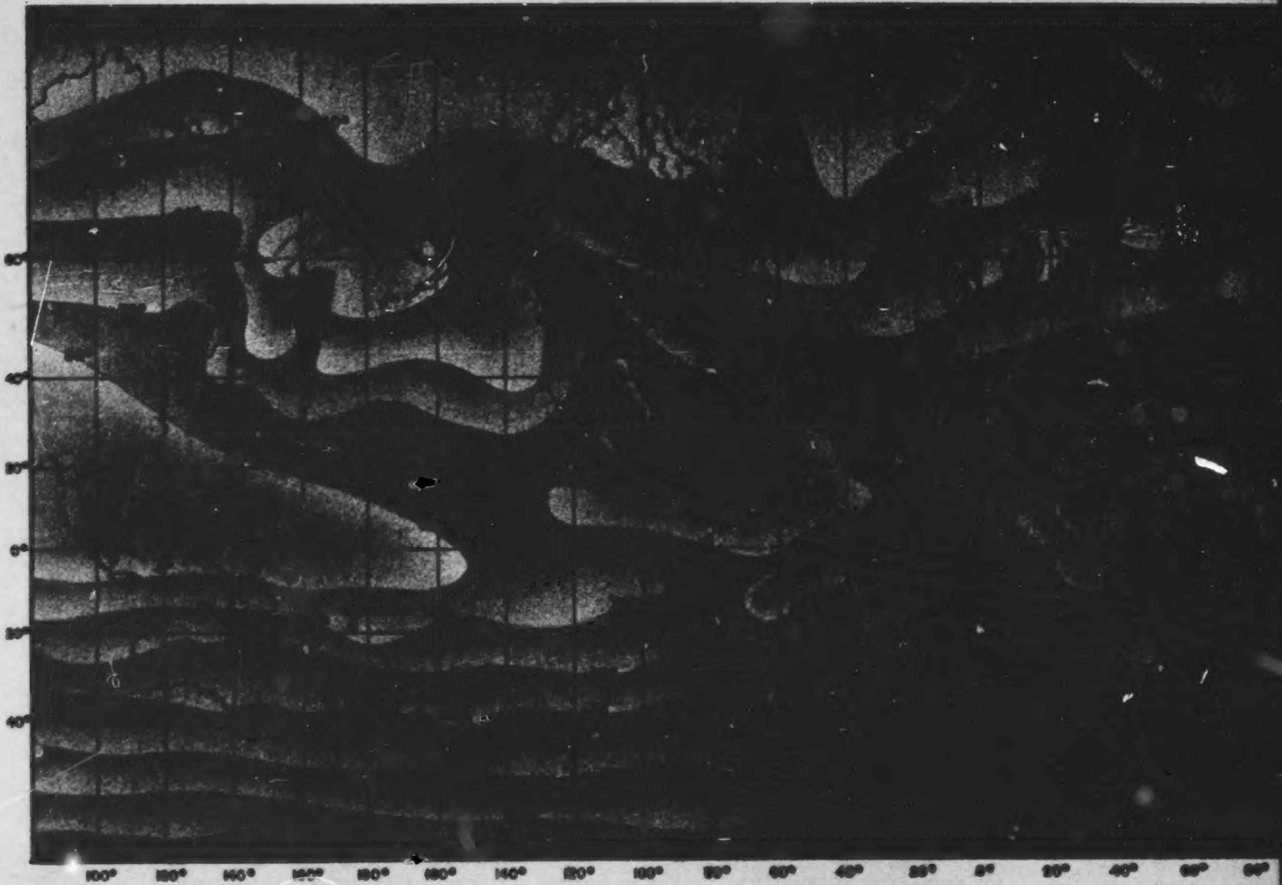
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Figure 13-1.—Mean world temperature for January and July.

160°
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160°
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100°
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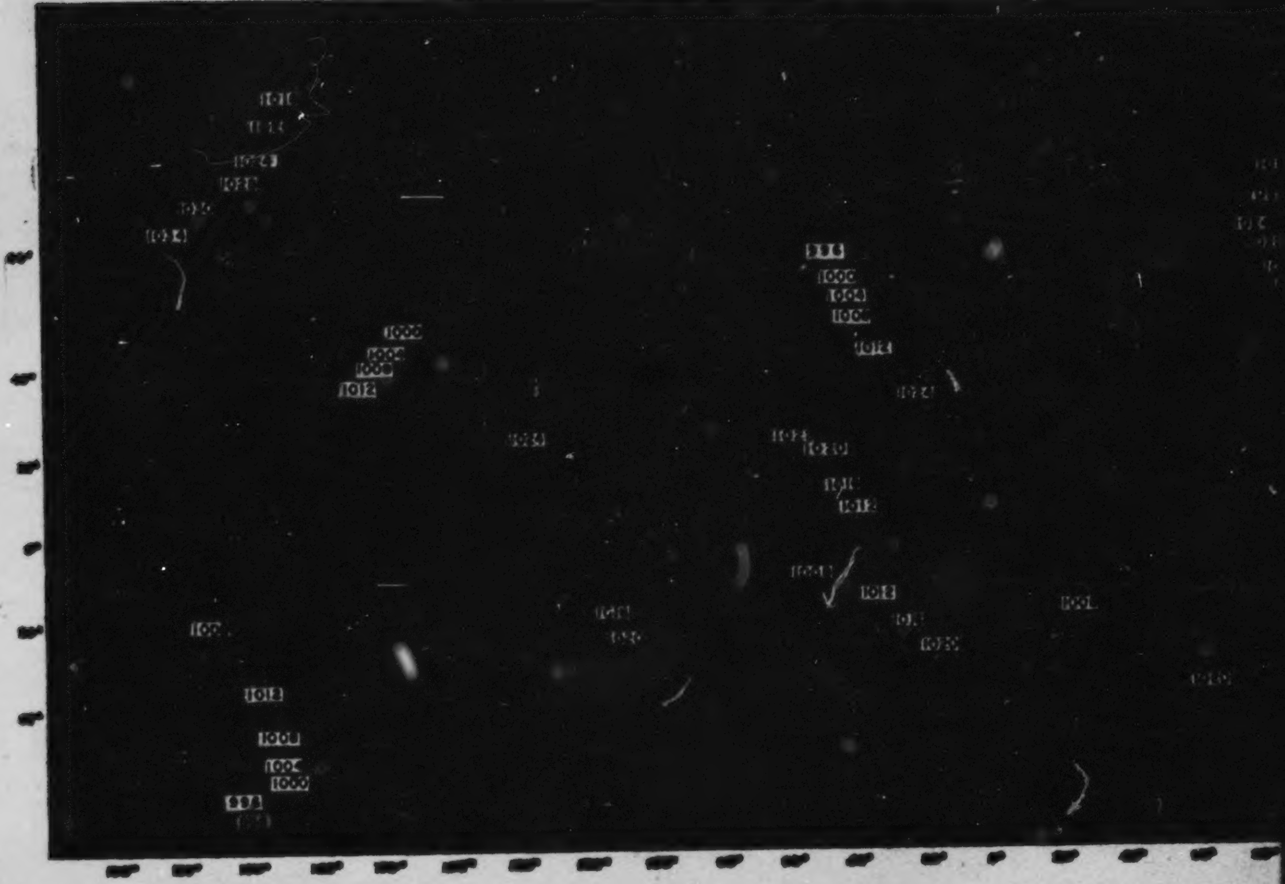
Figure 13-1.—Mean world temperature for January and July. 209.32.1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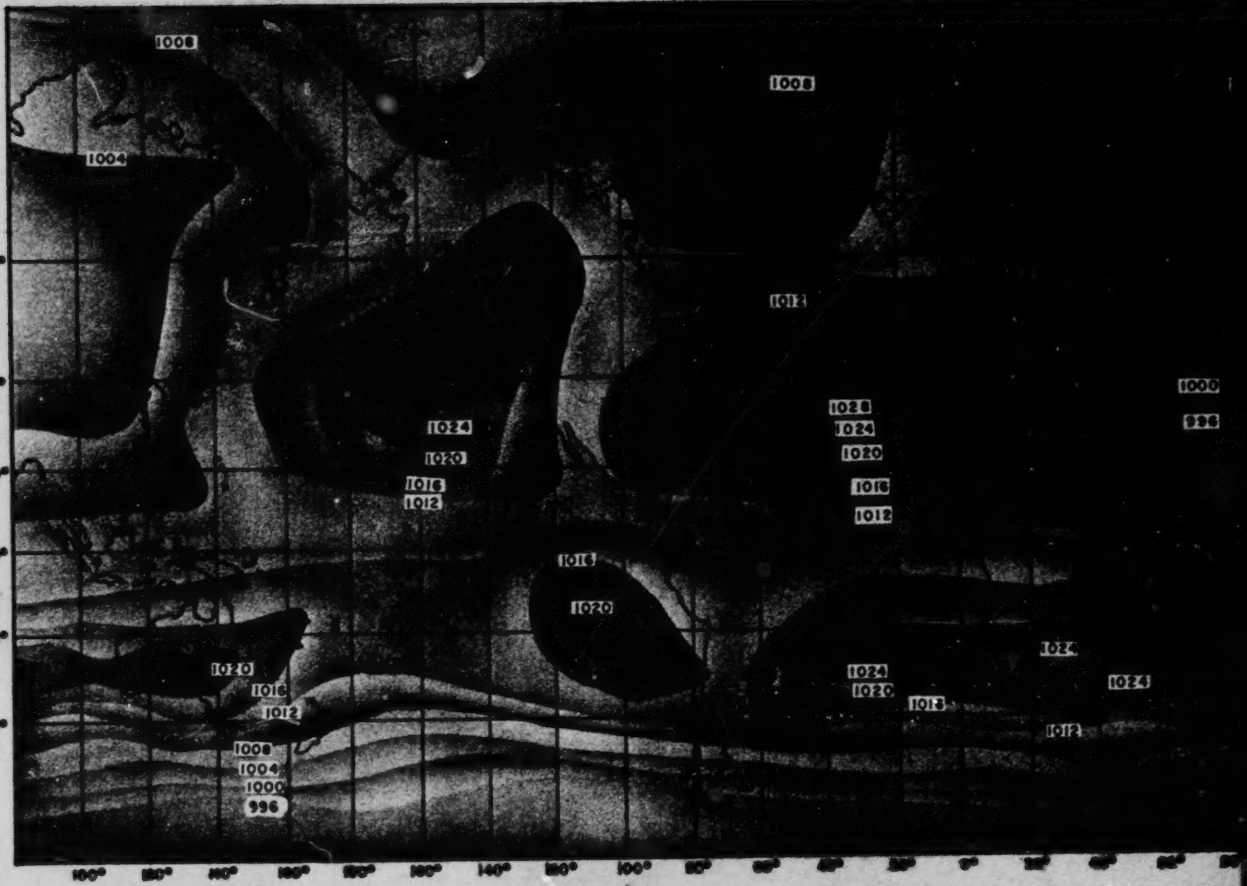
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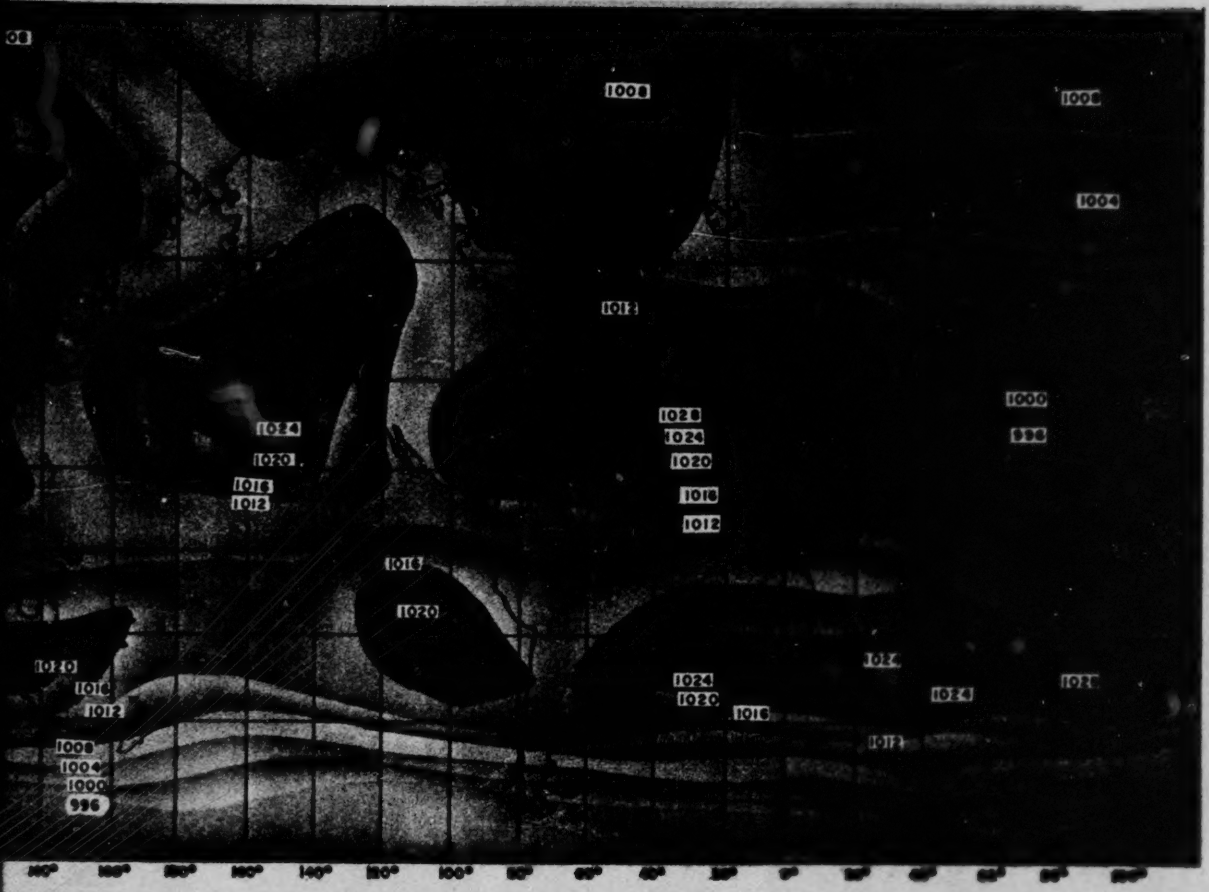
Figure 13-2.—Mean world pressure for January and July.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1012
140°
120°
100°

209.366

Figure 13-2.—Mean world pressure for January and July.

direct rays of the sun hit the earth near the Equator and cause a net gain of heat. The air at the Equator heats, rises, and flows in the upper atmosphere toward both poles. Upon reaching the poles, it cools and sinks back toward the earth, where it tends to flow along the surface of the earth back to the Equator. Simple circulation of the atmosphere would occur as described above if it were not for the following factors:

1. The earth rotates, resulting in an apparent force known as the Coriolis (or deflecting) effect described in chapter 12 and also resulting in constant change of the area being heated.
2. The earth is covered by irregular land and water surfaces.

Regions under the direct rays of the sun receive more heat per unit time than those under oblique rays. The heat brought by the slanting rays of early morning may be compared with the heat that is caused by the slanting rays of winter. The heat which is due to the more direct rays of midday may be compared with the heat resulting from the more direct rays of summer.

The length of day, like the angle of the sun's rays, influences the temperature. The length of day varies with the latitude and the season. Near the Equator there are about 12 hours of daylight every day in the year, and the sun at noonday is always high in the sky (giving nearly direct rays). Consequently, equatorial regions have no pronounced seasonal temperature changes.

During the summer in the Northern Hemisphere, all places north of the Equator have more than 12 hours of daylight. During the winter the situation is reversed, latitude north of the Equator having less than 12 hours of daylight.

Large seasonal variation in the length of the day and the seasonal difference in the angle at which the sun's rays reach the earth's surface cause seasonal temperature differences in middle and high latitudes.

The weak temperature gradient in the subtropical areas and the steeper gradient poleward can be seen in figure 13-1. Note also how much steeper the gradient is poleward in the winter season of each hemisphere than it is in the summer season.

PRESSURE OVER THE GLOBE

In the previous chapter it was stated that an increase in temperature causes air to expand and lowers its pressure and density, and vice versa. The unequal heating of the earth's surface due to its tilt, rotation, and differential insolation, results in the wide distribution of pressure over the earth's surface. In figure 13-2, note that a low-pressure area lies along the doldrums in the equatorial region. This is due to the higher temperatures maintained throughout the year in this region. At the poles, permanent high-pressure areas remain near the surface because of the low temperatures in this area throughout the entire year. The subtropical high-pressure areas at 30°N and S lat are caused mainly by the "piling up" of air in these regions. There are other areas which are dominated by relatively high or low pressures during certain seasons of the year.

ELEMENTS OF CIRCULATION

It has previously been shown how temperature differences cause pressure differences. Pressure differences in turn cause air movements. This section and the following sections of the chapter are designed to show Aerographer's Mates how the air movements work and how they evolve into the various circulations—general, secondary, and tertiary.

Static Earth

If the earth were a nonrotating sphere composed of a uniform surface, the atmospheric circulation would be relatively simple. The air at the Equator would be heated and become less dense, causing it to rise and expand. Due to less insolation at the poles, the air would be cooled and become denser, causing it to descend. Therefore, if the earth were static, the flow of air would be a simple circulation from the poles to the Equator at the surface, and from the Equator to the poles aloft. (Refer to chapter 12, fig. 12-6.)

Rotating Nonuniform Earth

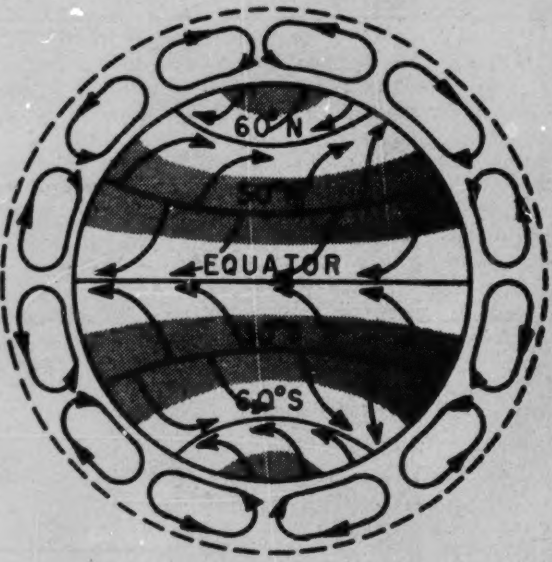
The earth is neither static nor uniform; consequently, the basic wind pattern is considerably different from the simple one described above.

Due to the rotation of the earth, the Coriolis effect causes a deflection of the winds to the right in the Northern Hemisphere and to the left in the Southern Hemisphere. (See fig. 13-3.) The complex circulation resulting from the interplay of the Coriolis effect with the flow of air is known as the 3-cell theory. (See fig. 13-4.)

THE 3-CELL THEORY

The rotation of the earth exerts a tremendous influence on the circulation of the earth's atmosphere. The 3-cell theory of the circulation offers an explanation of the effect of the earth's rotation.

According to the 3-cell theory, the earth is divided into six circulation belts—three in the Northern Hemisphere and three in the Southern Hemisphere. The dividing lines are the Equator, 30°N and S lat, and 60°N and S lat. The three cells of general circulation of the Northern Hemisphere are similar to those of the Southern Hemisphere.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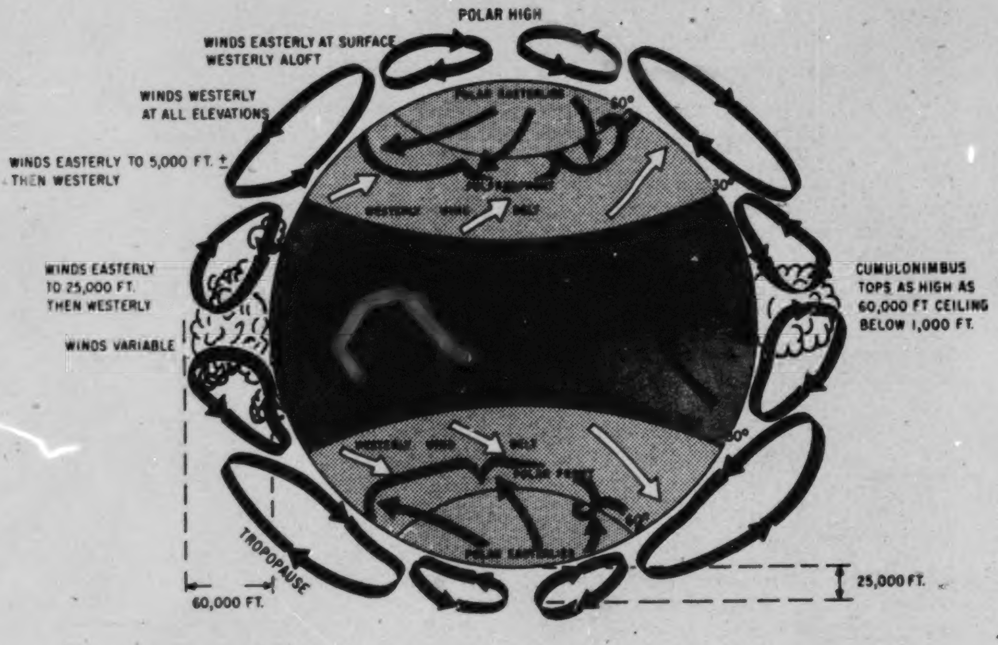
30°N
EQUATOR
60°S

209.36
Figure 13-3.—Coriolis effect on windflow.


POLAR HIGH
WINDS EASTERLY AT SURFACE
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WINDS WESTERLY
AT ALL ELEVATIONS
WINDS EASTERLY TO 5,000 FT. ±
THEN WESTERLY
WINDS EASTERLY
TO 25,000 FT.
THEN WESTERLY
WINDS VARIABLE
CUMULONIMBUS
TOPS AS HIGH AS
60,000 FT CEILING
BELOW 1,000 FT.
POLAR EASTERLIES
60°
POLAR FRONT
30°
WESTERLY WIND BELT
30°
WESTERLY WIND BELT
POLAR FRONT
60°
POLAR EASTERLIES
TROPOPAUSE
60,000 FT.
25,000 FT.

209.37
Figure 13-4.—Idealized pattern of the general circulation.

First, observe the tropical cell of the Northern Hemisphere which lies between the Equator and 30°N lat. The air at the Equator heats and rises. When it reaches the extremity of the troposphere, it tends to flow toward the North Pole. By the time the air has reached 30°N lat, the Coriolis effect has deflected it so much that it is moving eastward instead of northward. This results in a piling up of air near 30°N lat and a descending current of air toward the surface which forms a belt of high pressure. When the descending air reaches the surface, part of it flows poleward to become part of the midlatitude cell; the other part flows toward the Equator, is deflected by the Coriolis effect, and forms the northeast trades.

The midlatitude cell is located between 30° and 60°N lat. The air which comprises this cell circulates poleward at the surface and equatorward aloft with rising currents at 60° (polar front) and descending currents at 30° (high-pressure belt). However, in general, the winds, both at the surface and aloft, blow from the west. This is easily explained for the surface wind by the Coriolis effect on the poleward-moving surface air. The west wind aloft is not so easily explained. Most authorities agree that this wind is frictionally driven by the west winds in the two adjacent cells.

The polar cell lies between 60°N lat and the North Pole. The circulation in this cell begins with a flow of air at a high altitude toward the pole. This flow cools and descends at the North Pole and forms a high-pressure area in the polar regions. After reaching the surface of the earth, this air tends to flow equatorward and is deflected by the Coriolis effect so that it moves from the northeast. This air converges with the poleward flow from the midlatitude cell and is deflected upward with a portion circulating poleward again and the remainder equatorward. The outflow of air aloft between the polar and midlatitude cells causes a semipermanent low-pressure area at approximately 60°N lat and, due to the discontinuity in temperature and density of these two cells, the polar front develops in this area.

To complete the picture of the world's general atmospheric circulation, it is necessary that the prevailing winds and pressure belts be associated with their corresponding pressure belts along with some of the other basic characteristics.

World Winds

Corresponding with the doldrums or the intertropical convergence zone (ITCZ), there would be a belt of relatively low pressure.

The doldrums vary in position and tend to move north and south of the Equator with the sun, though more of the area is generally located slightly to the north of the Equator. In the region of the doldrums the temperatures are high, and the wind is convergent (a net inflow of air into the area), which results in excessive precipitation.

On the poleward side of the doldrums the TRADE WINDS are found. Whenever the doldrums are absent in some part of the equatorial region, the trade winds of the Northern and Southern Hemisphere converge, causing heavy rain squalls. A noticeable feature of the trade wind belt is the regularity of these systems, especially over the oceans.

The wind blowing above and counter to the trade wind is the ANTITRADE.

Near 30°N and 30°S latitudes lie the subtropical high-pressure belts. Winds are light and variable. These areas are referred to as the HORSE LATITUDES. Due to the descending air, fair weather is often characteristic of this region. The pressure decreases outward from this area, both northward and southward.

The prevailing westerlies, which are on the poleward side of the trade winds, are persistent throughout the midlatitudes. In the Northern Hemisphere their direction at the surface is from the southwest and in the Southern Hemisphere from the northwest, due to the deflection caused by the Coriolis effect as the air moves poleward.

Poleward of the prevailing westerlies, near 60°N and 60°S latitudes, lies the belt of low pressure known as the polar front zone. Here converging winds result in ascending air currents and consequent poor weather.

In the polar cells, high pressure exists at low levels as the cold dense air sinks.

Geostrophic and Gradient Winds

On a surface weather chart analysis, points of equal pressure are connected by drawn lines referred to as isobars, while in upper air analysis, points of equal heights are connected and called isoheights.

The variation of these heights and pressures from one locality to another is the initial factor that produces movement of air, or wind. Assume that at three stations the pressure is lower at each successive point. This means that there is a horizontal pressure gradient—a decrease in pressure in this case—for each unit distance. With this situation, the air moves from the area of greater pressure to the area of lesser pressure.

If the force of the pressure were the only factor acting on the wind, the wind would flow from high to low pressure, perpendicular to the isobars. Since experience shows the wind does not flow perpendicular to isobars, but at a slight angle across them and towards the lower pressure, it is evident that other factors are involved. These other factors are the Coriolis effect, caused by the rotation of the earth; frictional force, caused by the wind coming in contact with the surface over which it is passing; and centrifugal effect, due to the curvature of the isobars. If a unit of air moves with no friction force involved, the movement of air would be parallel to the isobars; this wind is termed a gradient wind if the isobars are curved so that centrifugal force as well as Coriolis and pressure gradient forces are involved, and a geostrophic wind if the isobars are straight so that only Coriolis and pressure gradient forces are involved.

In figure 13-5 you can see that the flow of air is from the area of high pressure to the area of low pressure, but as we mentioned previously, it does not flow straight across the isobars (or isoheights). Instead the flow is circular around the pressure systems. Recall that as previously stated, when the pressure gradient force (PGF) causes the air to begin moving from the high-pressure to the low-pressure system, the Coriolis (deflective) force and centrifugal force begin acting on the flow in varying degrees.

The Coriolis force commences deflecting the path of movement to the right (Northern Hemisphere) or left (Southern Hemisphere) until it reaches a point where a balance exists between the Coriolis and the pressure gradient force. At this point the air is no longer deflected and moves forward around the systems.

Once circular motion around the systems is established, then centrifugal force must be considered.

Centrifugal force acts outward from the center of both the highs and the lows with a force dependent upon the velocity of the wind and the degree of curvature of the isobars. However, the pressure gradient force is acting towards the low; therefore, the flow in that direction will persist. If while moving toward the low the flow is moving parallel to the curved portion of the analysis (fig. 13-5), it is termed a GRADIENT WIND. If it is moving parallel to that portion of the analysis showing straight flow, it is referred to as GEOSTROPHIC WIND.

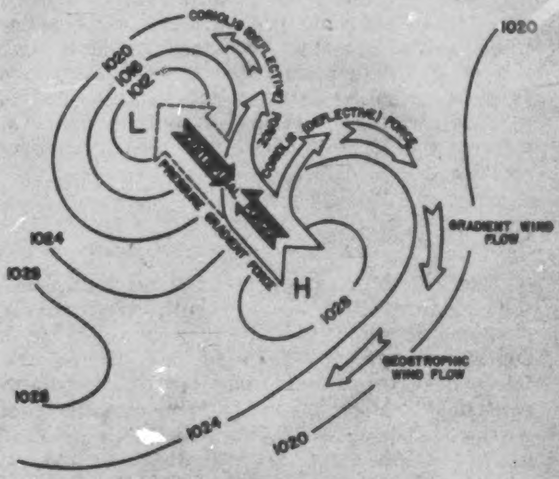

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Figure 13-5.—Examples of circulation about high and low pressure systems.

We defined pressure gradient as being a change of pressure with distance. This means that is our isobars are closely spaced, then the pressure change is greater over a given distance; it is smaller if they are widely spaced. Therefore, the closer the isobars, the faster the flow.

Frictional Force

Friction tends to retard air movement. Friction depends on the nature of the surface over which the air is moving. It is least over water surfaces and greatest over mountainous terrain. The effect of surface friction extends from the surface to approximately 3,000 feet. It is usually safe to say that the wind above 3,000 feet is the same as the gradient or geostrophic wind in direction and speed. Since the frictional effect decreases the speed of the air particles, the forces that are in balance with the pressure gradient when aloft are weakened when introduced to the frictional layer over the earth. This means that the pressure force is the dominating force at the surface, and the surface wind direction is pulled somewhat toward the direction of the pressure force. (See fig. 13-5.)

Cyclostrophic Wind

The Coriolis effect is at a minimum near the Equator; and as a result, the pressure gradient force is balanced primarily by the centrifugal effect. The wind that results when the pressure gradient force is balanced by the centrifugal effect is called the cyclostrophic wind. In the cyclostrophic wind, the pressure gradient force is inward-directed and the centrifugal effect is outward-directed. This is the balance of forces for a low-pressure system near the Equator. An example of cyclostrophic winds are the winds found in a hurricane.

Convergence and Divergence

Convergence is the condition that exists when the distribution of winds within a given area is such that there is a net horizontal inflow of air into an area. The removal of the resulting excess is accomplished by an upward movement of air; consequently, areas of convergent winds are regions favorable to the occurrence of precipitation.

Divergence is the condition that exists when the distribution of winds within a given area is such that there is a net outward horizontal flow of air from the area. The resulting deficit is compensated by a downward movement of air from aloft; areas of divergent winds are regions unfavorable for the occurrence of precipitation. Since the wind flows from higher to lower pressure areas, it can be seen that convergence is associated with low-pressure areas and divergence with high-pressure areas. (See fig. 13-6.)

WORLD CLIMATE

Weather can be a valuable ally when you understand the climatic patterns, the natural factors which govern and regulate weather changes, and the weather possibilities of different or distant regions of the earth. A study of climate and climatology of a region can also help to avoid or minimize the hazards it holds.

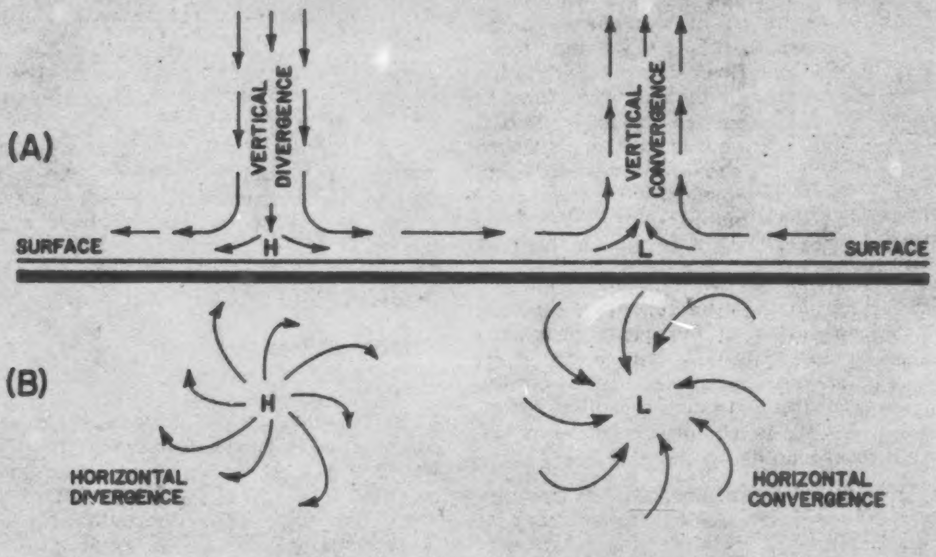

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Figure 13-6. — Convergence and divergence. (A) Vertical perspective; (B) Horizontal perspective. (Northern Hemisphere).

Climate Defined

Climate is defined as the average or collective state of the earth's atmosphere at any given location or area within a specified period of time. We think of weather as the day-to-day changes in the atmosphere. On the other hand, the climate of an area is determined over periods of many years and represents the general weather characteristics of an area or locality.

Classification of Climate

The climate of a given region or locality is determined by a combination of several meteorological elements, and not just one element alone. For example, two regions may have similar temperature climates but very different precipitation climates. Their climatic difference therefore becomes apparent only if more than one climatic factor is considered.

Since the climate of a region is composed of all the averages of the various climatic elements, such as dew, ice, rain, temperature, wind force, and wind direction, it is obvious that no two locations have exactly the same climate. However, it is possible to place similar areas into a grouping known as a climatic zone.

Climatic Zones

The basic grouping of climatic zones consists of classifying climates into five broad belts based on astronomical or mathematical grounds. Actually they are zones of sunshine, or solar climate. The five basic regions or zones are the Torrid or Tropical Zone, the two Temperate Zones, and the two Polar Zones. The Tropical Zone is limited on the north by the Tropic of Cancer and on the south by the Tropic of Capricorn, which are located at 23 1/2° N and S lat, respectively. The Temperate Zone of the Northern Hemisphere is limited on the south by the Tropic of Cancer and on the north by the Arctic Circle, which is located at 66 1/2° N lat. The Temperate Zone of the Southern Hemisphere is bounded on the north by the Tropic of Capricorn and on the south by the Antarctic Circle, which is located at 66 1/2° S lat. The two Polar Zones are the areas in the polar regions which have the Arctic and Antarctic Circles as their boundaries. The Polar Zones are sometimes called the Frigid Zones.

A glance at any chart depicting the isotherms over the surface of the earth will show that the isotherms do not coincide with latitude lines. In fact, at some places the isotherms parallel the longitude lines more closely than they parallel the latitude lines. The astronomical or light zones therefore differ from the zones of heat. A closer approach to the understanding of climate can be made if the climatic zones are limited by isotherms rather than by parallels of latitude. (See fig. 13-7.)

Climatic Types

Any classification of climate depends to a large extent on the purpose of the classification. A classification for the purpose of establishing air stations, for instance, where favorable flying conditions are important, would differ considerably from one for establishing the limits of areas that are favorable for the growing of crops. Consequently, several classification systems have evolved and are described in detail in climatology texts.

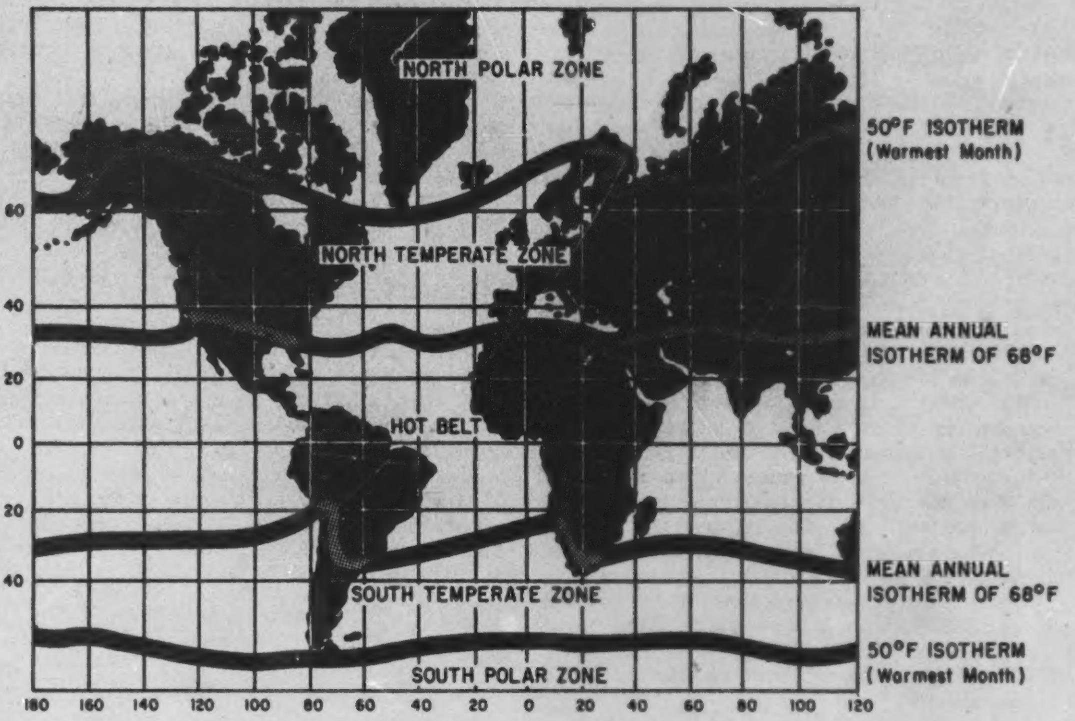
Climatic Controls

The variation of climatic elements from place to place and from season to season is caused by several factors called climatic controls. The same basic factors that cause weather in the atmosphere also determine the climate of an area. These controls, acting in different combinations and with varying intensities, act upon temperature, precipitation, humidity, air pressure, and winds to produce many types of weather and therefore climate.

Four factors largely determine the climate of every ocean and continental region. They are as follows:

1. Latitude.
2. Land and water distribution.
3. Topography.
4. Ocean currents.

LATITUDE.—Perhaps no other climatic control has such a marked effect upon climatic elements as does the latitude, or the position of the earth relative to the sun. The angle at which rays of sunlight reach the earth and the number of "sun" hours each day depend upon


NORTH POLAR ZONE
50°F ISOTHERM
(Warmest Month)
NORTH TEMPERATE ZONE
MEAN ANNUAL
ISOTHERM OF 68°F
HOT BELT
MEAN ANNUAL
ISOTHERM OF 68°F
SOUTH TEMPERATE ZONE
50°F ISOTHERM
(Warmest Month)
SOUTH POLAR ZONE
60
40
20
0
20
40
180
160
140
120
100
80
60
40
20
0
20
40
60
80
100
120

210.2

Figure 13-7. — Temperature zones.

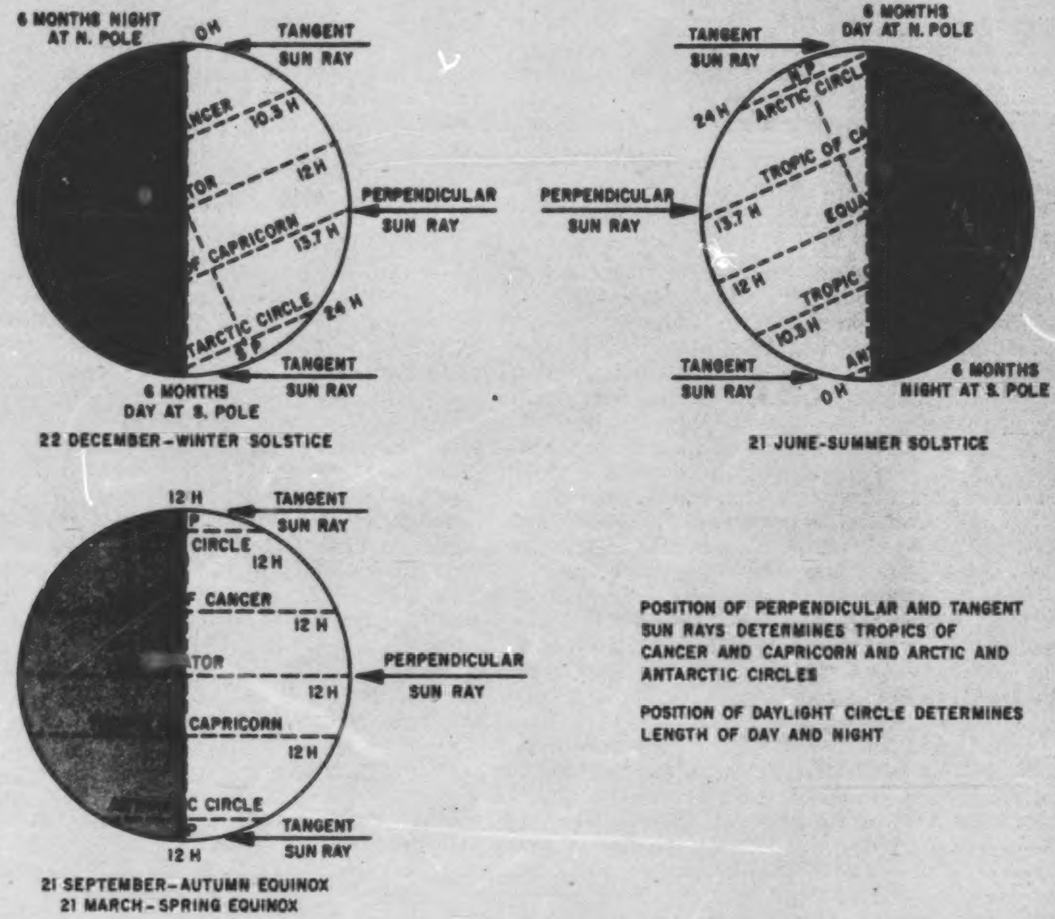
the distance from the Equator. (See fig. 13-8.) Therefore, the extent to which an air mass is heated is influenced by the latitude.

Influence on Air Temperature. — Regions under direct or nearly direct rays of the sun receive more heat (per unit of time) than those under oblique rays. The heat brought about by the slanting rays of early morning may be compared with the heat that is caused by the slanting rays of winter. The heat which is due to the more nearly direct rays of midday may be compared with the heat resulting from the more nearly direct rays of summer.

The length of the day, like the angle of the sun's rays, influences the temperature. The length of the day varies with the latitude and the season of the year.

The hot and humid climates of equatorial Africa and South America are good examples of the influence that latitude has on climate. At no time during the year are the sun's rays at much of an oblique angle. Therefore, there is little difference between the mean temperatures for the coldest and warmest month. Contrast this picture with the opposite extreme, such as in the far north, where the sun is below the horizon for a great deal of the time during the winter, producing cold temperatures that breed powerful polar outbreaks. During the long hours of summer daylight the sun's rays make such a small angle with the earth's surface that the energy received per unit area is extremely small and the sun's effectiveness is minimized even though it may shine for days without ceasing. It is, however, sufficient to thaw lakes and weaken the polar air masses.

LAND AND WATER DISTRIBUTION. — Because land and water heat and cool at different


6 MONTHS NIGHT AT N. POLE
0 H
TANGENT SUN RAY
NCER
10.3 H
TOR
12 H
PERPENDICULAR SUN RAY
F CAPRICORN
13.7 H
TARCTIC CIRCLE
24 H
S P
TANGENT SUN RAY
6 MONTHS DAY AT S. POLE
6 MONTHS DAY AT N. POLE
TANGENT SUN RAY
N P
24 H
ARCTIC CIRCL
TROPIC OF CA
PERPENDICULAR SUN RAY
13.7 H
EQUA
12 H
TROPIC O
10.3 H
AN
TANGENT SUN RAY
0 H
6 MONTHS NIGHT AT S. POLE
12 H
TANGENT SUN RAY
P
CIRCLE
12 H
F CANCER
12 H
TOR
PERPENDICULAR SUN RAY
12 H
CAPRICORN
12 H
C CIRCLE
P
TANGENT SUN RAY
12 H

22 DECEMBER–WINTER SOLSTICE

21 JUNE–SUMMER SOLSTICE

21 SEPTEMBER–AUTUMN EQUINOX
21 MARCH–SPRING EQUINOX

POSITION OF PERPENDICULAR AND TANGENT SUN RAYS DETERMINES TROPICS OF CANCER AND CAPRICORN AND ARCTIC AND ANTARCTIC CIRCLES

POSITION OF DAYLIGHT CIRCLE DETERMINES LENGTH OF DAY AND NIGHT

210.3

Figure 13-8.—Latitude differences in amount of insolation.

rates, the location of continents and oceans greatly alters the earth pattern of air temperature and influences the sources and direction of movement of air masses.

Influence on Air Temperature.—Coastal areas take on the temperature characteristics of the land or water to their windward. In latitudes of prevailing westerly winds, for example, west coasts of continents have oceanic temperatures and east coasts have continental temperatures. The temperatures are determined by the windflow.

Since the upper layers of the ocean are nearly always in a state of violent stirring, heat losses or heat gains occurring at the sea surface are distributed throughout a large volume of water. This mixing process sharply reduces the temperature contrasts between day and night and between winter and summer over oceanic areas.

Land surfaces are not subject to such a mixing process, and the effect of conduction is negligible. Thus, violent contrasts between seasons and between day and night are created in the interiors of continents. During winter, a large part of the sparsely incident solar radiation is reflected back toward space by the snow cover that extends over large portions of the northern continents. For these reasons, the northern continents serve as manufacturing plants for dry polar air. The polar air cap is no longer symmetrical, but is displaced far to the south, particularly over the interior of Asia.

The large temperature difference between the land and water surface, which reverses between the two seasons, determines to a great extent the seasonal weather patterns.

You will note in figure 13-1 that in the Northern Hemisphere, the temperature gradient is greater in winter than in summer, and is more regular in winter. Note also how the isotherms are more closely spaced and parallel in winter. In the Southern Hemisphere, the temperature gradient does not have as great a seasonal change as it does in the Northern Hemisphere. This is due to the unequal distribution of land and water on the two hemispheres. Since the Southern Hemisphere has less land and more water surface than the Northern Hemisphere, the change due to the greater water surface is less with consequently more nearly uniform isotherms. Too, the continents of the Southern Hemisphere taper toward the poles and do not extend to as high a latitude as in the Northern Hemisphere.

The nature of the surface affects the local heat distribution. Color, texture, and vegetation influence the rate of heating and cooling. Generally, dry surfaces heat and cool faster than moist surfaces. Plowed fields, sandy beaches, and paved roads become hotter than surrounding meadows and wooded areas. During the day, air is warmer over a plowed field than over a forest or swamp; during the night the situation is reversed.

The distribution of water vapor and cloudiness is another important factor influencing air temperature. Although areas with a high percentage of cloudiness have a high degree of reflectivity, the energy which is not reflected is easily trapped in the lower layers due to the greenhouse effect. Thus, it must be expected that areas of high annual moisture content will have relatively high annual temperature.

Influence on Air Circulation.—The higher mean temperature of the Northern Hemisphere is not only an effect of its greater land cover, but the oceans are also warmer than in the Southern Hemisphere. This is partly due to the movement of warm equatorial waters from the Southern Hemisphere into the Northern Hemisphere, caused by the southeast trades which cross the Equator. Another factor conducive to higher mean temperatures in the Northern Hemisphere is the partial protection of its oceans from cold polar waters and Arctic ice by land barriers. There is no such barrier between the Antarctic region and the southern oceans.

TOPOGRAPHY.—Over land climates may vary radically within very short distances because of land forms and the variations with altitudes. In this section we will discuss these two general effects.

Altitude.—The height of an area above sea level exerts a considerable influence on its climate. For instance, a place located on the Equator in the high Andes of South America would have a climate quite different from a place located a few feet above sea level at the same latitude.

A change of all climatic values is observed as a function of elevation.

Mountain Barriers.—A powerful influence on climates is mountainous terrain, especially the long high chains of mountains that act as climatic divides. These obstacles deflect the tracks of cyclones and block the passage of air masses in the lower levels. If the pressure gradients are strong enough to force the air masses over the mountains, the forced ascent and descent will modify the air masses to a great extent, thus modifying the climate on both the windward and leeward sides.

The orientation of the mountain range may block certain air masses and keep them from getting to the lee side of the mountains. For example, the Himalayas and the Alps, with an east-west orientation, prevent fresh polar air masses from advancing southward. Therefore, the climates of India and Italy are warmer in winter than other locations of the same latitude. The coastal ranges of mountains in North America, running in a north-south line, prevent the passage of unmodified maritime air masses to the lee side.

Probably the most noted effect of mountains is the distribution of precipitation. The values, level for level, are much higher on the windward side.

In regions where a westerly circulation is predominant, the amounts of precipitation increase more or less uniformly up to the tops of mountains to elevations of about 10,000 feet. However, in the trade wind zone, such as at the Hawaiian Islands, precipitation amounts increase only to about 3,000 feet and then decrease gradually. Even with this decrease in amounts, more rain is received at 6,000 feet than at sea level.

OCEAN CURRENTS.—The ocean currents, which are produced mainly by the prevailing winds of the earth, exert a considerable effect upon the climates of many regions of the earth. Ocean currents will be discussed in detail along with their climatic effects in chapter 16.

SECONDARY CIRCULATIONS

The general circulation is modified by the distribution of land and water over the surface of the earth, causing uneven heating and cooling of the earth's surface, and also the changes in heating which result from the change in seasons.

CENTERS OF ACTION

When diagrams showing the distribution of mean surface temperatures are compared with those showing mean sea level pressures, (figs. 13-1 and 13-2) it can readily be seen that the pressure belts of the primary circulation are rarely continuous, but are broken up into detached areas of high and low pressure cells by the secondary circulation. The break corresponds with regions showing differences in temperature from land to water surfaces. These cells which tend to persist in a particular area are called centers of action; that is, they are found at nearly the same location with somewhat similar intensity during the same month each year.

There is a permanent belt of relatively low pressure along the Equator and another deeper belt of low pressure paralleling the coast of the Antarctic Continent. Permanent belts of high pressure largely encircle the earth, particularly over the oceans, in both the Northern Hemisphere and Southern Hemisphere, with a number of centers of maximums about 30 to 35 degrees from the Equator.

Seasonal Variations

There are regions where the pressure is predominantly low or high with the changing seasons. The pressure over land during the winter is decidedly above the annual average and decidedly below it during the summer.

In the vicinity of Iceland, pressure is low most of the time. The water surface is warmer than the icecaps of Greenland and Iceland. The Icelandic low is most intense in winter, when the greatest temperature differences occur, but it persists with less intensity through the summer. The Aleutian low is most pronounced when the neighboring areas of Alaska and Siberia are snow-covered and colder than the adjacent ocean.

These lows are not a continuation of one and the same cyclone. They are regions of low pressure, where lows frequently form or arrive from other regions to remain stationary or move sluggishly for a time, after which they pass on or die out and are replaced by others. Occasionally these regions of low pressure are invaded by traveling high-pressure systems.

There are semipermanent high-pressure centers over the Pacific to the west of California and in the Atlantic between the African coast and Azores. Pressure is also high, but less persistently so, west of the Azores to the vicinity of Bermuda.

These subtropical highs reach their greatest intensity during the summer, and the area over which they extend is much greater and the pressure higher in summer. In winter these subtropical highs are found at lower latitudes and migrate poleward with the onset of the summer season and equatorward with the winter season.

The largest individual circulation cells in the Northern Hemisphere are the Asiatic high in winter and the Asiatic low in summer. In winter, the Asiatic continent is a region of strong cooling and therefore is dominated by a large high-pressure cell. In summer, strong heating is present, and the high-pressure cell becomes a large low-pressure cell. This seasonal change in pressure cells gives rise to the monsoonal flow of the India-Burma area.

Another cell which some consider to be a center of action is the polar high. The polar high in winter is not a cell centered directly over the North Pole, but it appears to be an extension of the Asiatic high and often appears as a wedge extending from the Asiatic Continent. The cell is displaced toward the area of coldest temperatures, the Asiatic Continent. In summer, this high appears as an extension of the Pacific high and is again displaced toward the area of coolest temperature, which in this case is the extensive water area of the Pacific.

In winter over North America, the most significant feature is the domination by high-pressure cells. These cells are also due to cooling but are not as intense as the Asiatic cells. The Greenland high, for example, due to the Greenland icecap, is a persistent feature, but it is not a well-defined high during all seasons of the year. It often appears to be an extension of the polar high, or vice versa.

Recent explorations into both the Arctic and the Antarctic have revealed considerable variations in pressure in these regions and the presence of many traveling disturbances during the summer months.

Other continental regions show seasonal variations from low pressure in summer, but are generally of small size, and their location is variable. Therefore, they are not considered to be centers of action.

In summer, the most significant feature is the so-called heat low over the southwestern part of the continent which is caused by extreme heating in this region.

MIGRATORY SYSTEMS

General (primary) circulation of the atmosphere, based on an average of wind conditions, is a more or less quasi-stationary circulation. Likewise, much of the secondary circulation depends on more or less static conditions which, in turn, depend on permanent and semipermanent high-pressure and low-pressure areas. Changes in the circulation patterns thus far discussed have been largely seasonal. However, secondary circulation also includes wind systems which migrate constantly, producing rapidly changing weather conditions, especially in the middle latitudes throughout all seasons.

The migratory systems of circulation are associated with air masses, fronts, cyclones, and anticyclones. Air masses and fronts are covered in detail in the next chapter.

Anticyclones

An anticyclone is an area of relatively high pressure having the wind circulation in a clockwise direction in the Northern Hemisphere and counterclockwise in the Southern Hemisphere. The windflow in an anticyclone is slightly across the isobars and away from the center of the anticyclone. (See fig. 13-9.) Anticyclones are commonly called highs or high-pressure areas.

The formation of an anticyclone or the intensification of an existing one is called anticyclogenesis. The decreasing of the intensity of an anticyclone is called anticyclolysis.

The vertical extent of pressure depends greatly on the air temperature. Since density increases with a decrease in temperature, pressure decreases more rapidly along the vertical in colder air than in warmer air.

In a cold anticyclone (such as the Siberian high), the vertical extent is shallow; while in a warm anticyclone (such as the subtropical high), the vertical extent reaches high into the upper atmosphere due to the slow decrease in temperature with elevation.

When thinking of highs, lows, anticyclones, and cyclones, do not confuse the terms. A cyclone is a low, and an anticyclone is a high. The terms "cyclone," "anticyclone," "low," and "high" refer to the wind circulation and to the atmospheric pressure.

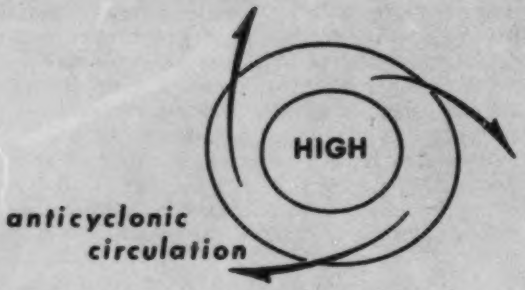


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Figure 13-9. — Anticyclones.

Cyclones

A cyclone is a circular or nearly circular area of low atmospheric pressure around which the winds blow counterclockwise, and slightly across the isobars toward the center in the Northern Hemisphere. The direction of rotation is opposite, or clockwise, in the Southern Hemisphere. It is commonly called a low or a depression. This use of the word "cyclone" should be distinguished from the colloquial use of the word as applied to the tornado. (See fig. 13-10.)

The formation of a new cyclone or the intensification of an existing one is called CYCLOGENESIS. Cyclogenesis usually occurs with DEEPENING (a decrease in atmospheric pressure), but the terms are not synonymous. The decrease and eventual extinction of a cyclone is called CYCLOLYSIS. Cyclolysis refers to circulation in the atmosphere and should not be confused with FILLING (an increase in atmospheric pressure), although the two processes usually occur together.

Cyclones in middle and high latitudes are referred to as extratropical cyclones, and the tropical cyclones are referred to as hurricanes, typhoons, baguios, or willy-willies, depending on their geographical location. (Tropical cyclones are discussed in chapter 14.)

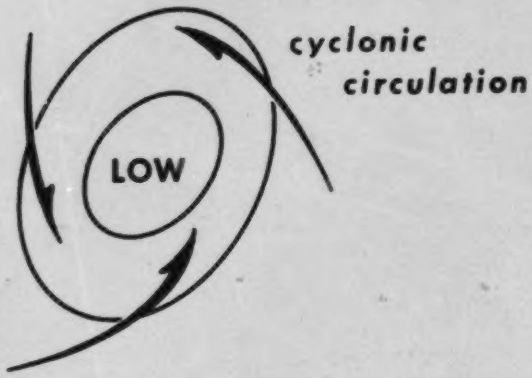

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Figure 13-10.—Cyclone.

MONSOON WINDS

The term "monsoon" is of Arabic origin and means season. The monsoon wind is a seasonal wind that blows from continental interiors (or large land areas) to the ocean in the winter, and in the opposite direction during the summer. The monsoon wind is most pronounced over India, although there are other regions with noticeable monsoon winds. Over India the monsoons blow from the northeast during January and from the southwest in July, and are caused in the winter by the air blowing out of the high-pressure area of Siberia and in the summer by the wind flowing into the low-pressure area over central Asia. (See fig. 13-11.)

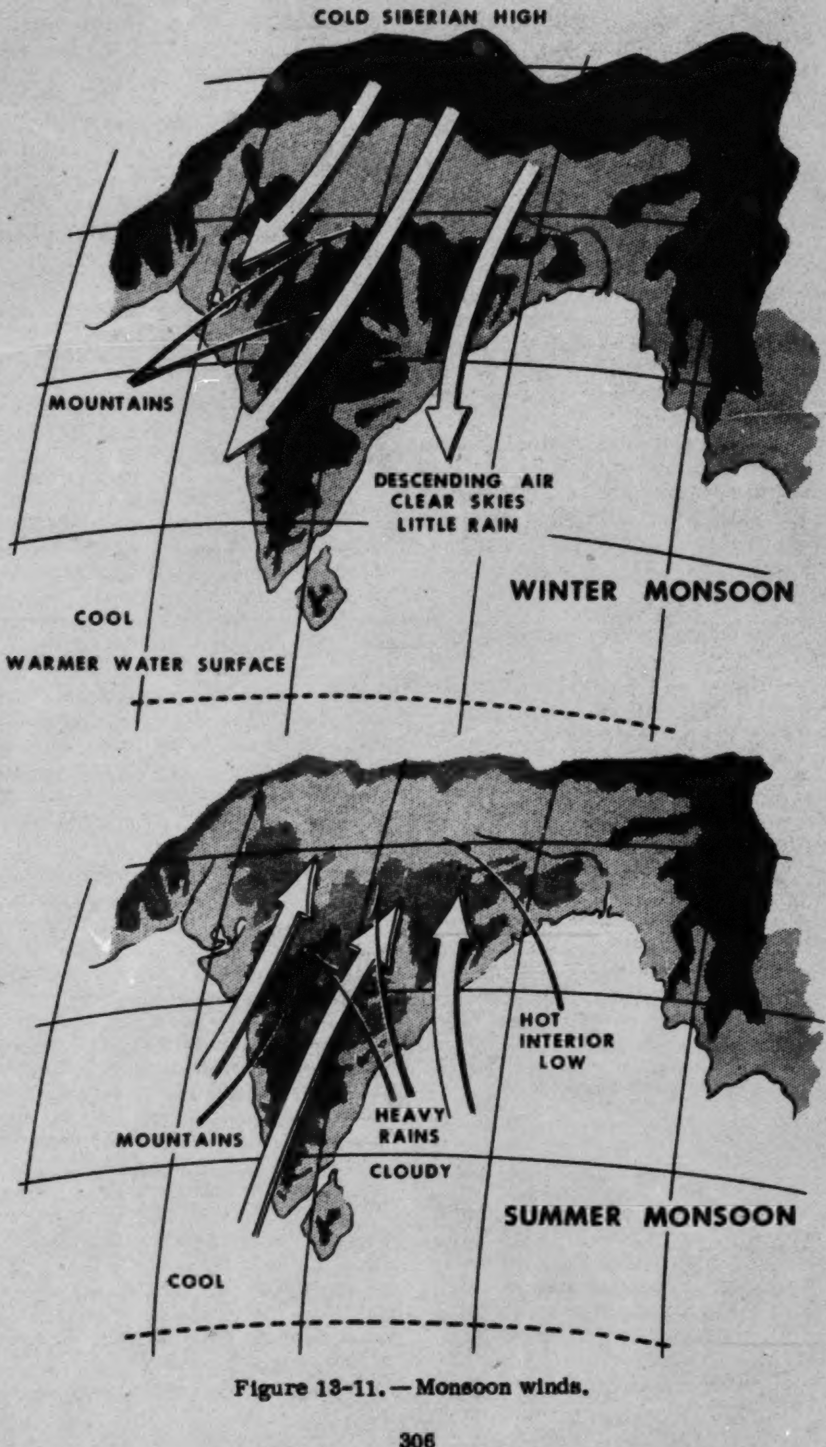
In summer the weather associated with monsoon winds is almost constant rain. This condition is caused by mass motion of air from the relatively high-pressure area over the ocean to a low-pressure area over land. When the air leaves the ocean, it is warm and moist. As the air travels over land toward the low-pressure area, it is also traveling from a lower altitude to a higher altitude. The air is lifted mechanically and cooled to its condensation point by this upslope motion.

In winter the weather situation is the reverse of summer. Clear skies predominate during this season. This is caused by the mass motion of air from a high-pressure area over land to an area of lower pressure over the ocean. As the air leaves the high-pressure area over land, it is cold and dry. As it travels over land toward the ocean, there is no source of moisture to induce precipitation. The air is also traveling from a higher altitude to a lower altitude; consequently, this downslope motion causes the air to be warmed at the adiabatic lapse rate. This warming process has a still further clearing effect on the skies.

JETSTREAM

The jetstream is a special circulation; however, since it is so closely associated with secondary circulations of the migratory type, it is discussed here.

The term, jetstream, is defined as relatively strong winds concentrated within a narrow stream in the atmosphere. While this term may be applied to any such stream regardless of direction, it is commonly interpreted to mean a band or belt of winds with a strong westerly component which meanders around the globe. By saying that it has a strong westerly component, it is meant that it flows primarily from the west or from adjacent directions such as northwest or southwest. By saying that it meanders, it is meant that it is not found at the same latitude or elevation all around the earth at the same time, but it has a wavelike trajectory. It may range from 25 to 100 miles in


COLD SIBERIAN HIGH
MOUNTAINS
DESCENDING AIR
CLEAR SKIES
LITTLE RAIN
WINTER MONSOON
COOL
WARMER WATER SURFACE
HOT
INTERIOR
LOW
MOUNTAINS
HEAVY
RAINS
CLOUDY
SUMMER MONSOON
COOL

209.42

Figure 13-11.—Monsoon winds.

width and up to a mile or two in depth. Sometimes the jetstream is a continuous band, but more often it is broken or split at several points.

Jetstreams are found in both the Northern Hemisphere and the Southern Hemisphere, but much more is known about the predominant one in the Northern Hemisphere. This is the one normally referred to when only the term "jetstream" is used. It is located in the high tropopause along the boundary of the polar front zone where there is extreme horizontal temperature contrast. Normally, there is a break in the tropopause where the jetstream exists, or it may be said that it exists where the tropopause has its greatest slope.

The winds in the jetstream occasionally exceed 250 knots. Most of the time the winds range from about 100 to 150 knots. However, a band of winds is classed as a jetstream only when the winds in the band have a speed of 50 knots or more. The jetstream is stronger in winter than in summer.

It is closely associated with migratory low-pressure systems and the polar front. Most of the time there are no signs of a jetstream on the surface. The jetstream increases in intensity with elevation to just below the tropopause where its maximum speed is reached. Thereafter, it decreases in intensity again.

The jetstream is very important both in forecasting weather and in naval flight operations. In forecasting the weather, it is important relative to the development and the movement of fronts and low-pressure systems. In naval flight operations, it is important as something to be avoided when the flight plan goes against it, and as something that can be used to gain time when the flight plan is with the wind direction. A 150-knot wind can increase or decrease the ground speed of an aircraft to a large extent, depending on the direction of the flight relative to the wind.

TERTIARY CIRCULATIONS

Many regions have local weather phenomena caused by temperature differences between land and water areas or by local topographical features. Those weather phenomena which show up as circulations of air and are due to local features are termed tertiary (third order) circulations. A knowledge of these circulations which have a significant effect on the local weather conditions is important for Aerographer's Mates.

LAND AND SEA BREEZES

There is a daily contrast of heating of local water and land areas similar to the seasonal variation. During the day, the land is warmer than the water area, and at night the land area is cooler than the water area. A slight variation in pressure is caused by this temperature contrast. At night the wind blows from land to sea and is called a land breeze. During the day, the wind blows from water areas to land areas and is called a sea breeze. These breezes are shallow and do not penetrate far inland. Often in the middle and higher latitudes, these breezes are not noticeable, due to stronger winds of other character. (See fig. 13-12.)

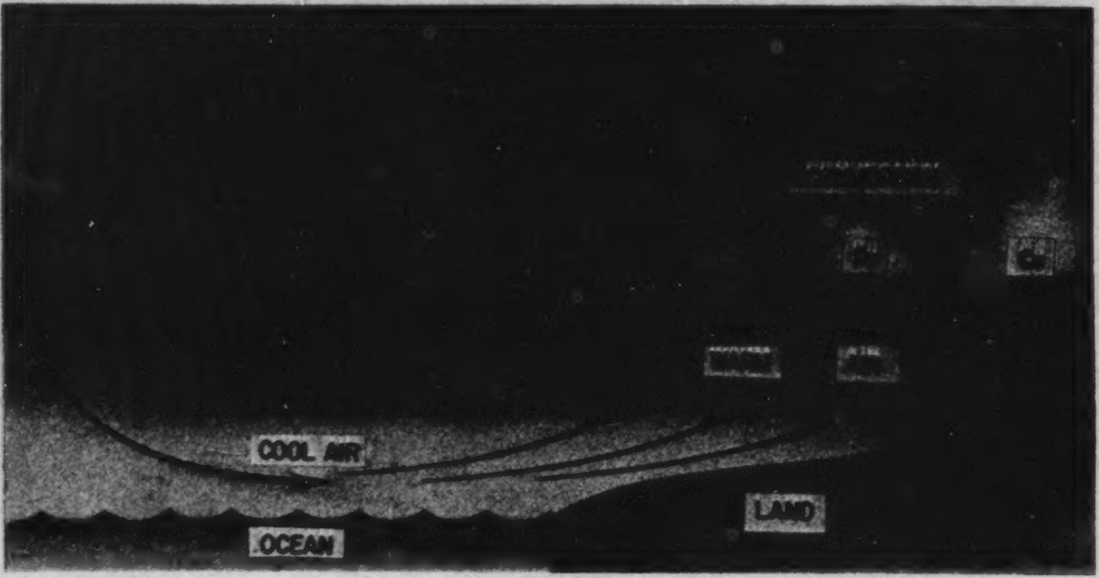
The sea breeze is most pronounced in late spring and summer; the land breeze is most pronounced in late fall and early winter.

MOUNTAIN AND VALLEY WINDS

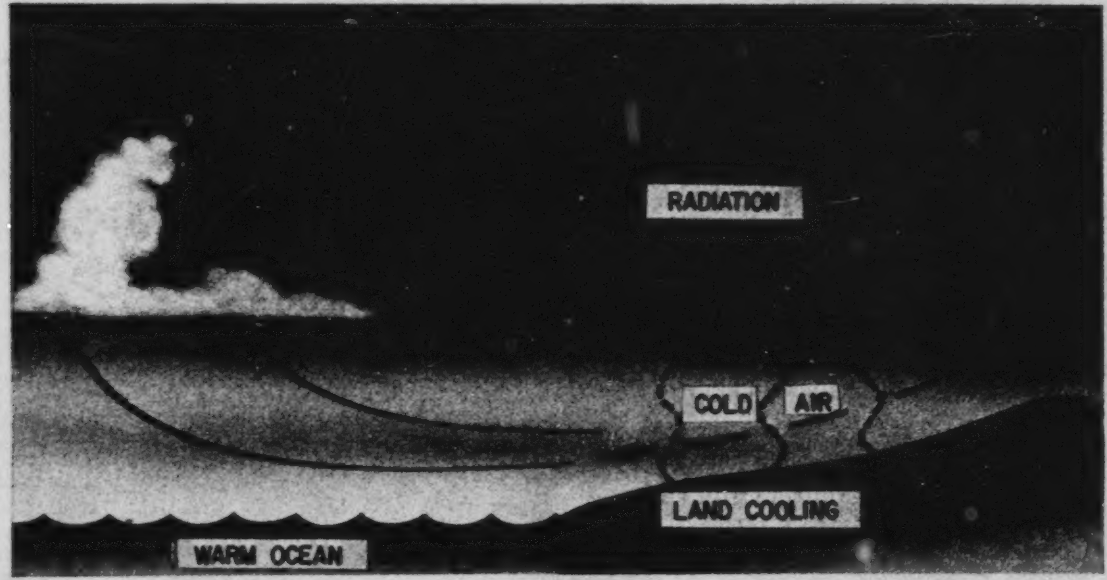
During the day, mountain slopes are warmer than the surrounding atmosphere at the same level; this heating effect causes the wind to flow upward from the valley area along the mountain slopes and is called a "valley wind." At night the situation is reversed, and the slopes become colder than the surrounding atmosphere; this cools the atmosphere in the lower levels near the surface of the slopes and causes the wind to flow downward into the valley. This wind is referred to as a "mountain wind." Winds ascending a mountain slope are called ANABATIC winds. At times these anabatic winds are unnoticeable due to the effects of vertical convection. The reverse of the anabatic wind is the KATABATIC wind. Hence, the katabatic wind occurs when the wind flows down the slope. (See figs. 13-13 and 13-14.)

FOEHN WINDS

The foehn wind is a warm dry wind with a strong downward component on the leeward side of mountains. When air flows up and over a mountain barrier, it undergoes expansion and cools at the dry adiabatic lapse rate (1°C per 100 meters) until the temperature drops to the


COOL AIR
LAND
OCEAN

SEA BREEZE


RADIATION
COLD
AIR
LAND COOLING
WARM OCEAN

LAND BREEZE

209.43

Figure 13-12.—Circulation of land and sea breezes.

209.44
Figure 13-13.—Valley or anabatic wind. During the daytime hillsides heat quickly. This heating effect causes updrafts along upslopes—downdrafts in the center.

209.45
Figure 13-14.—Mountain or katabatic wind. During the night outgoing radiation cools air along hillsides below free air temperature. The cooled air drains to lowest point of the terrain.

dewpoint. Condensation occurs, and a cloud forms above the mountain with possible precipitation on the windward side of the mountain. During the descent of the air on the leeward side of the mountain, heating takes place, due to compression, again at the dry adiabatic lapse rate. These winds are characteristic of the Alps, and also of the Rockies, where they are known as chinook winds.

FUNNEL EFFECT

Winds blowing against mountain barriers tend to flatten out and go around them. If the barrier is broken by a pass or a valley, the air is forced through the break with considerable speed. Such forcing of wind through narrow valleys is known as the funnel effect. A good example of the funnel effect is the Santa Ana wind of Southern California. This type of wind is discussed in chapter 12 in the section entitled "Bernoulli's Theorem."

GLACIER WINDS

Glacier winds, or fall winds as they are sometimes called, occur in a great variety in all parts of the world where there are glaciers or elevated land masses that become covered by snow and ice during winter. During winter, the area of snow cover becomes most extensive, permitting a maximum amount of radiational cooling and consequently cooling of the surrounding air coming in contact with the cold surfaces. This cooling effect makes the air denser, therefore heavier than the surrounding air. When this air is set in motion, it flows down the sides of the glacier or plateau. Drainage winds of this variety cover a wide range—from light local breezes that descend through the valleys from small isolated glaciers to the violent outbreaks of cold air that rush down the lee side of a continental ice plateau. The latter is caused by the development of a gradient wind that sets in motion the reservoir of extremely cold air from the high-level snowfields. These winds in many areas occur as violent squalls of short duration when a mass of cold air is released over the edge of a cold plateau and plunges down through an adjacent valley or fjord to sea level.

When a changing pressure gradient moves a large cold air mass over the edge of a plateau, this action sets in motion the strongest, most persistent, and most extensive of the glacier or fall winds. When this happens, the fall velocity is added to the pressure gradient force so that the cold air rushes down to sea level along a front which may extend for hundreds of miles. This condition occurs in winter on a large scale along the edge of the Greenland icecap, where in some places the wind attains a velocity in excess of 90 knots for days at a time and reaches more than 150 miles out to sea.

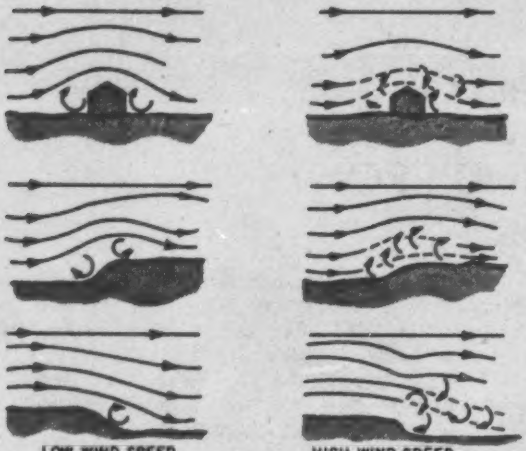
Since all of the drainage winds are heated adiabatically in their descent, they are predominantly dry. Occasionally, the glacier winds pick up moisture by falling precipitation when they underride warm air. All glacier or fall winds are essentially cold winds, even with the adiabatic heating which they undergo, because of the extreme coldness of the air in its source region. Contrary to all other descending winds which are warm and dry, the glacier wind is cold and dry. It is colder, level for level, than the air mass it is displacing. In the Northern Hemisphere the glacier winds descend frequently from the snow-covered plateaus and glaciers of Alaska, Canada, Greenland, and Norway.

EDDIES AND TURBULENCE

Turbulence is the irregular motion of the atmosphere when the air flows over an uneven surface, or when two currents of air flow past each other in different directions or at different speeds. The main source of turbulence is the friction along the surface of the earth. This is called mechanical turbulence. Turbulence is also caused by irregular temperature distribution. The warmer air rises and the colder air descends, causing an irregular vertical motion of air; this is called thermal turbulence.

Mechanical turbulence is intensified in unstable air and is weakened in stable air. These influences cause fluctuations in the wind with periods ranging from a few minutes to more than an hour. If these wind variations are strong, they are called wind squalls and are usually associated with convective-type clouds. They are an indication of approaching towering cumulus or cumulonimbus clouds.

Gustiness and turbulence are more or less synonymous. Gustiness is the irregularity in the wind speed which creates eddy currents disrupting the smooth air flow. Thus, the term



LOW WIND SPEED (BELOW 20 MPH)

HIGH WIND SPEED (ABOVE 20 MPH)

210.37

Figure 13-15.—Eddy currents formed when wind flows over uneven ground or obstructions.

''gustiness'' is usually used in conjunction with sudden intermittent increases in the wind speed near the surface levels, and turbulence is used with reference to levels above the surface. Gustiness can be measured by wind instruments, whereas turbulence, unless encountered by aircraft equipped with a gust probe or an accelerometer, is usually estimated.

An eddy is the more or less circular motion of the wind produced by an obstruction in its path, such as irregularities on the earth's surface (hills and mountains), trees, and buildings. The length of an obstacle and the stability of the air are the factors which determine whether the air will flow around or across the object. Turbulence caused by large objects, such as buildings, is usually a combination of horizontal and vertical eddies. (See fig. 13-15.)

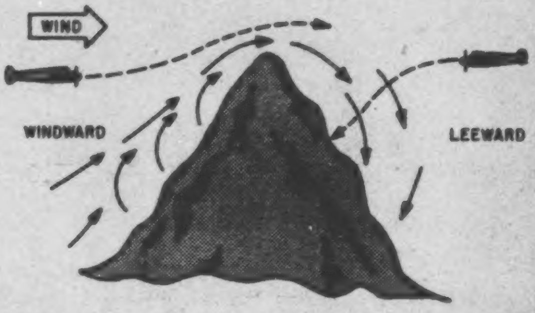


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Figure 3-16.—Effect of windflow over mountains.

There may be a stationary eddy on the windward side of a mountain if the windward side has a steep slope. The leeward side of mountains has the most pronounced eddy activity, and in most cases violent downdrafts exist. The downdrafts are extremely dangerous to aircraft, and instances are recorded of their having caused aircraft to crash into mountain sides. (See fig. 13-16.)

CHAPTER 14

AIR MASSES AND FRONTS

Personnel studying for advancement to Aerographer's Mate Third Class or Second Class must know a great deal about air masses and fronts. In this chapter a more complete picture of the part that air masses and fronts play in the overall weather story is given. It is readily seen that air masses and fronts are the keys to modern weather analysis and forecasting.

AIR MASSES

The air-mass concept is one of the most important developments in the history of meteorology. An air mass is a large body of air whose physical properties, particularly temperature and moisture distribution, are nearly homogeneous, level for level. Forecasting is largely a matter of recognizing the various air masses in the weather picture, determining their characteristics, and predicting their behavior.

CLASSIFICATION

Air masses have been classified geographically and thermodynamically. The geographical classification, which refers to the source region of the air mass, divides air masses into four basic categories. These are arctic/antarctic (A), polar (P), tropical (T), and equatorial (E). Some authors may include superior (S) or monsoon (M) in their classification. The first three are further divided into maritime (m) and continental (c). Maritime arctic/antarctic air masses are rare, since there is a predominance of land mass or icefields in the polar regions. Virtually all equatorial air masses are considered to be maritime in origin. An air mass is considered to be maritime if its source of origin is over an oceanic surface. If the air mass originates over a land surface, it is considered continental.

The less common air masses, superior and monsoon, are limited in locale and extent. The superior (S) air mass is generally found aloft over the southwestern United States, but is sometimes located at or near the surface. Monsoon air (M), as the name implies, is found over India and southeastern Asia.

The types of air masses can easily be remembered by using the letters in the word "tape" to stand for the first letter of each basic type of air mass.

The thermodynamical classification applies to the relative warmth or coldness of the air mass. A warm air mass (w) is one which is warmer than the underlying surface; a cold air mass (k) is one which is colder than the underlying surface. For example, a continental polar cold air mass is classified as cPk. An mTw classification indicates that the air mass is a maritime tropical warm air mass.

Air masses can usually be identified by the type of clouds within them. Cold air masses usually show cumuliform clouds, whereas warm air masses contain stratiform clouds.

Sometimes, and with some air masses, the thermodynamic classification may change from night to day. A particular air mass may show k characteristics during the day and w characteristics at night and vice versa.

SOURCE REGIONS

The air-mass source region is the area where the air mass originates. The condition which is ideal for the production of an air mass is the stagnation of air over a rather uniform surface (water, land, or icecap) of uniform temperature and humidity. The length of time an air mass stagnates over its source region depends on the surrounding pressures. The air acquires definite properties and characteristics, from the surface up, and becomes virtually homogeneous throughout, and its properties become rather uniform at each level. In the middle latitudes, the land and sea areas with the associated steep latitudinal temperature gradient are generally not homogeneous enough for source regions. These areas act as transitional zones for air masses after they have left their source regions.

The source regions for the world's air masses are shown in figure 14-1. Note the uniformity of the underlying surfaces; also note the relatively uniform climatic conditions in the various source regions, such as the southern North Atlantic and Pacific Oceans for maritime tropical air and the deep interiors of North America and Asia for continental polar air.

Arctic Air

There is a permanent high-pressure area in the vicinity of the North Pole, within which is found the arctic air-mass source region. In this region there is a gentle flow of air over the polar icefields, allowing the formation of the arctic air mass. The air is characterized by being dry aloft and very cold and stable in the lower altitudes.

Antarctic Air

This air is developed in the antarctic region. It is colder at the surface and other levels than arctic air in fall and winter.

Continental Polar Air

The continental polar source regions consist of all the land areas dominated by the Canadian and Siberian high-pressure cells. In the winter these regions are covered by snow and ice. Because of the intense cold and the absence of water bodies, very little moisture is taken into the air in these regions. Note that the word "polar" when applied to air-mass designations does not mean air at the poles (this area is covered by the words arctic and antarctic). Polar air is generally found between 40° and 60° latitude and except for that found over northern and central Asia, is generally warmer than arctic air.

Maritime Polar Air

The maritime polar source regions consist of the open unfrozen polar sea areas in the vicinity of 60° latitude, north and south. Such areas are sources of moisture for polar air masses; consequently, air masses forming over these regions are moist, but the moisture is sharply limited by the temperature.

Continental Tropical Air

The continental tropical source regions can be any significant land areas lying in the tropical regions, generally between 25° north latitude and 25° south latitude. The large land areas found there are usually desert regions, such as the Sahara or Kalahari Deserts of Africa, the Arabian Desert, and the interior of Australia. The air over these land areas is hot and dry.

Maritime Tropical Air

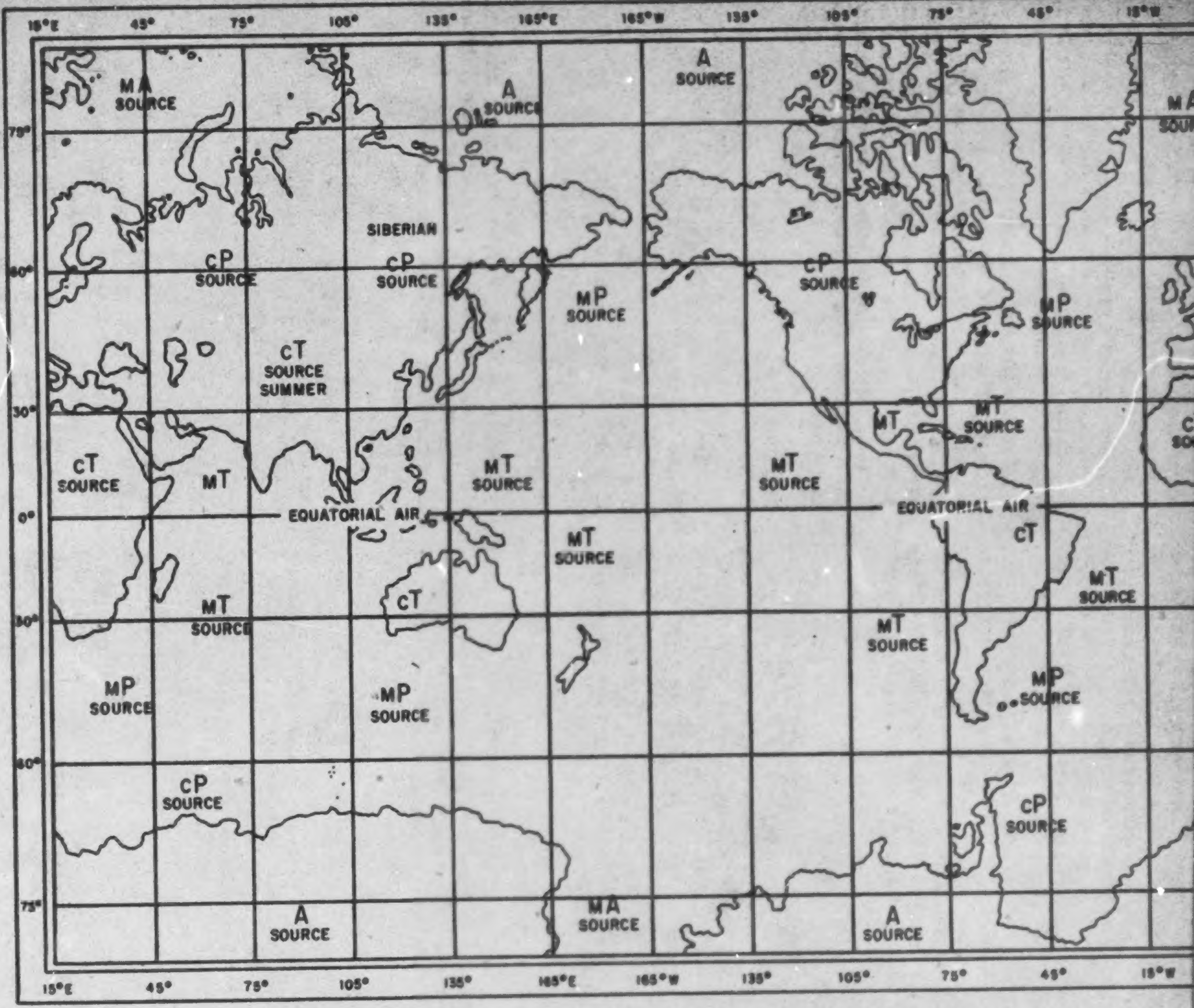
The maritime tropical source regions are the large zones of tropical sea along the belt of the subtropical anticyclones. High-pressure cells stagnate in this area most of the year. The air is warm due to low latitude and is able to hold considerable moisture.

Equatorial Air

The equatorial source region is the area from about 10° north to 10° south latitudes within which the thermal Equator is found. It is essentially an oceanic belt which is very warm and has a high moisture content. Convergence of the trade winds from both hemispheres and the intense insolation over this region causes lifting of the air, which is unstable and moist, to high levels. The weather associated with these conditions is characterized by thunderstorms throughout the year.

MODIFICATION

When an air mass moves out of its source region, there are a number of factors which act upon the air mass to change its properties. These modifying influences do not occur separately. For instance, in the passage of cold air over warmer water surfaces, there is not only a release of heat to the air, but also some moisture.


15°E
45°
75°
105°
135°
165°E
165°W
135°
105°
75°
45°
15°W
75°
60°
30°
0°
30°
60°
75°
MA SOURCE
A SOURCE
A SOURCE
SIBERIAN
cP SOURCE
cP SOURCE
MP SOURCE
cP SOURCE
MP SOURCE
cT SOURCE SUMMER
cT SOURCE
MT
EQUATORIAL AIR
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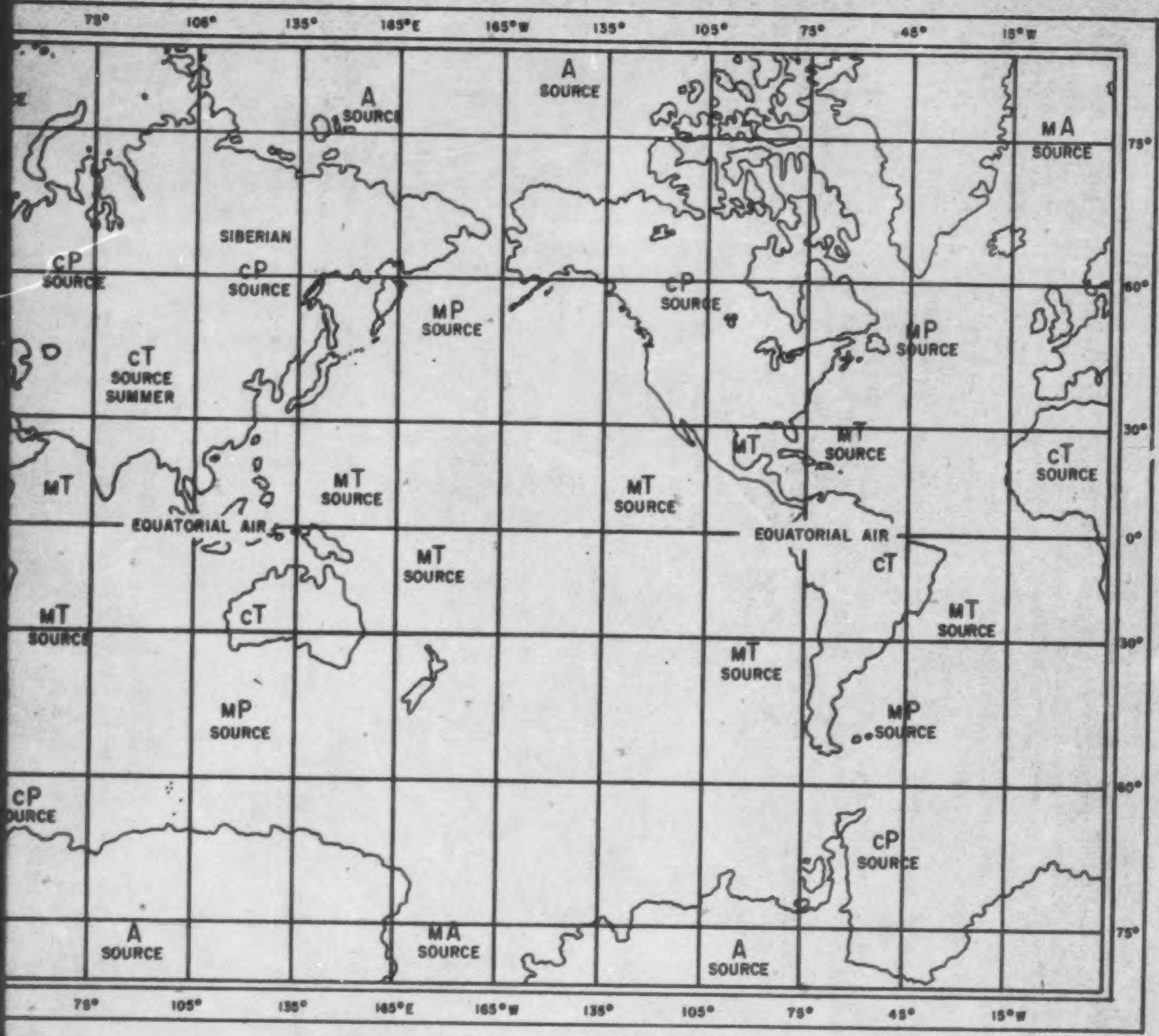
MT SOURCE
MT SOURCE
MT SOURCE
MP SOURCE
MP SOURCE
MP SOURCE
cP SOURCE
cP SOURCE
A SOURCE
MA SOURCE
A SOURCE

Figure 14-1.—Air mass source regions.


75°
105°
135°
165°E
165°W
135°
105°
75°
45°
15°W
A SOURCE
A SOURCE
mA SOURCE
75°
SIBERIAN
cP SOURCE
cP SOURCE
cP SOURCE
mP SOURCE
60°
mP SOURCE
cT SOURCE SUMMER
30°
mT
mT SOURCE
mT
mT SOURCE
cT SOURCE
EQUATORIAL AIR
EQUATORIAL AIR
0°
mT SOURCE
cT
cT
mT SOURCE
mT SOURCE
30°
mT SOURCE
mP SOURCE
mP SOURCE
cP SOURCE
60°
cP SOURCE
A SOURCE
mA SOURCE
A SOURCE
75°
75°
105°
135°
165°E
165°W
135°
105°
75°
45°
15°W

209.57

Figure 14-1.—Air mass source regions.

As an air mass expands and slowly moves out of its source region, it travels along a certain path. The surface over which this path takes the air mass after leaving its source modifies the air mass. The type of trajectory, whether cyclonic or anticyclonic, also has a bearing on its modification. The time the air mass has been out of its source region will determine to a great extent the characteristics of the air mass when a thermodynamic classification is attempted.

Surface Conditions

The first modifying factor on an air mass as it leaves its source region is the type and condition of the surface over which it travels. Here, the factors of surface temperature, moisture, and topography must be considered.

TEMPERATURE.—The temperature of the surface relative to that of the air mass will modify not only the temperature, but its stability as well. For example, if the air mass is warm and moves over a colder surface, such as tropical air moving over colder water, the cold surface cools the lower layers of the air mass and its stability is increased. This stability will extend to the upper layers in time, and condensation in the form of fog or low stratus normally occurs.

If the air mass moves over a surface that is warmer, such as polar continental air moving out from the continent in winter over warmer water, the warm water heats the lower layers of the air mass, increasing instability and consequently spreading to higher layers.

The changes in stability of the air mass give valuable indications of the cloud types that will form, as well as the type of precipitation. Also, the increase or decrease in stability gives further indications of the lower layer turbulence and visibility.

MOISTURE.—The air mass may be modified in its moisture content by the addition of moisture by evaporation or by the removal of moisture by condensation and precipitation. If the air mass is moving over continental regions, the existence of unfrozen bodies of water can greatly modify the air mass and, in the case of an air mass moving from a continent to an ocean, the modification can be considerable. In general, dependent upon the temperature of the two surfaces, the movement over a water surface will increase the moisture content of the lower layers, and the relative temperature of the surface.

For example, the passage of cold air over a warm water surface will decrease the stability of the air with resultant vertical currents. The passage of warm moist air over a cold surface increases the stability and could result in fog as the air is cooled.

TOPOGRAPHY.—The effect of topography is evident primarily in the regions of mountains. The air mass is modified on the windward side by the removal of moisture through precipitation with a decrease in stability; and as the air descends on the other side of the mountain, the stability increases as the air becomes warmer and drier.

Trajectory

After an air mass has left its source region, the trajectory it follows, whether cyclonic or anticyclonic, has a great effect on its stability. If the air follows a cyclonic trajectory, its stability in the upper levels is decreased; this instability is a reflection of the cyclonic relative vorticity. The stability of the lower layers is not greatly affected by this process. On the other hand, if the trajectory is anticyclonic, its stability in the upper levels is increased as a result of subsidence associated with anticyclonic relative vorticity.

Age

Although the age of an air mass in itself cannot modify the air mass, it will determine, to a great extent, the amount of modification that takes place. For example, an air mass that has recently moved from its source region will not have had time to become modified significantly. However, an air mass which has moved into a new region and stagnated for some time, and is now old, will be found to have lost many of its original characteristics.

Summary

In table 14-1 the two modifying influences are classified thermal and mechanical. The table

Table 14-1. — Thermal and Mechanical Air Mass Modifications

THE PROCESS	WHAT TAKES PLACE	RESULTS
A. THERMAL		
1. Heating from below.	Air mass passes from over a cold surface to a warm surface, or surface under air mass is heated by sun.	Decrease in stability.
2. Cooling from below.	Air mass passes from over a warm surface to a cold surface, OR radiational cooling of surface under air mass takes place.	Increase in stability.
3. Addition of moisture.	By evaporation from water, ice, or snow surfaces, or moist ground, or from raindrops or other precipitation which falls from overrunning saturated air currents.	Decrease in stability.
4. Removal of moisture.	By condensation and precipitation from the air mass.	Increase in stability.
B. MECHANICAL		
1. Turbulent mixing.	Up- and down-draft.	Tends to result in a thorough mixing of the air through the layer where the turbulence exists.
2. Sinking.	Movement down from above colder air masses or descent from high elevations to lowlands, subsidence and lateral spreading.	Increases stability.
3. Lifting.	Movement up over colder air masses or over elevations of land or to compensate for air at the same level converging.	Decreases stability.

indicates the modifying process, what takes place, and the resultant change in stability of the air mass. It must be reiterated that these processes do not occur independently, but two or more processes are usually in evidence at the same time. It must also be stressed that the conditions indicated are only average conditions and that each individual case may be quite different.

WEATHER

Within an air mass, weather is controlled primarily by the moisture content of the air, the relationship between surface temperature and temperature of the air mass trajectory and topography (upslope or downslope). Rising air is cooled; descending air is warmed. Condensation takes place when the air is cooled to its dewpoint. A cloud warmed above the dewpoint temperature evaporates and dissipates. Stability tends to increase if the surface temperature is lowered or if the temperature of the air at higher levels is increased while the surface temperature remains the same. Stability tends to be reduced if the surface temperature remains the same and the temperature aloft is lowered.

Smooth stratiform clouds are associated with stable air, whereas turbulence, convective clouds, and thunderstorms are associated with unstable air.

Winter Air Masses

The following paragraphs primarily describe winter air-mass weather of North America. Significant features of air masses of the rest of the world are also pointed out.

CONTINENTAL ARCTIC (cA).—Continental arctic air, either k or w, is the coldest air over North America; however, the cooling rarely extends above 700 mb (10,000 ft). Continental arctic air is designated k and has an unstable lapse rate in the lower layers. The stability of cA air, though, depends primarily on its trajectory. If the path of cA air is cyclonic, instability, snow flurries, and low cloudiness result (especially in the Hudson Bay to Great Lakes region). East of the Appalachians, cAk air produces little weather. When cAk air has an anticyclonic trajectory, the weather is fair (as in the Midwest).

Elsewhere in the world, continental arctic air is significant only over western Europe and the Antarctic Continent. The appearance of cA over western Europe is infrequent; when cA air does appear, it is heavily modified and unstable, though quite cold.

The Antarctic Continent is the spawning ground for cA air in the Southern Hemisphere, but this air seldom leaves that continent. When it does leave, it rapidly becomes mP air. The coldest air mass in the world is the antarctic cA air mass.

CONTINENTAL POLAR (cP).—When a cP air mass moves out of its source region over warmer land, the lower layers of the air are gradually heated and the stability is decreased. As long as the air is moving over a snow-covered surface, the decrease in stability does not completely eliminate the stable characteristics acquired in the higher levels at the source region. Usually an outbreak of continental polar air is accompanied by winds of 15 knots or more, and this wind helps decrease the stable conditions in the lower levels. If this modified air moves rapidly over rough terrain, the turbulence will result in low stratocumulus clouds and occasional snow flurries. (See fig. 14-2.)

After the air passes over the snow-covered regions and moves over a surface having a temperature above freezing, rapid changes in air properties normally occur. The surface temperature increases rapidly and soon eliminates the stable conditions that had existed.

Since the heating from below is more rapid than the addition of moisture, the relative humidity is decreased. Under this condition, the condensation level rises and skies are generally clear.

A particularly troublesome situation often arises when the cold air flows from a cold, snow-covered surface to a water surface, and then over a cold, snow-covered surface again. This frequently happens with air crossing the Great Lakes. Air flowing over the water surface is heated rapidly near the surface and may eventually become unstable. Also, water vapor is added quickly to the air by evaporation from the relatively warm water surface. The air becomes saturated, or nearly so. Water vapor may be added to such an extent that steam fog

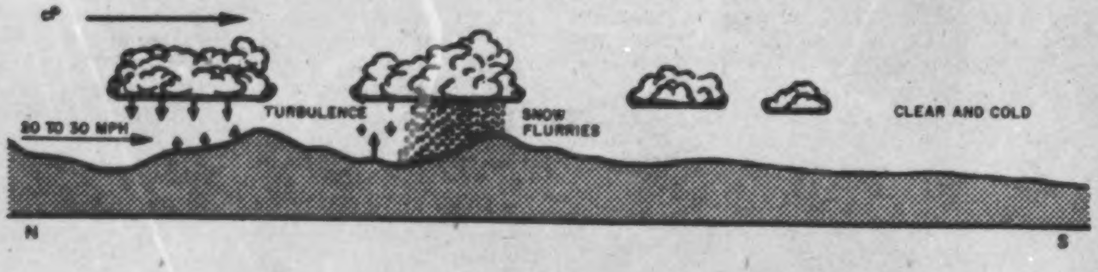


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Figure 14-2.—cP air moving southward.

forms. Thus, evaporation may continue from the warm water even after the cold air has become saturated, resulting in condensation. This condensation appears as fog, but due to the instability of the air, the steam is lifted as it forms, growing into clouds. After crossing the lakes, this air again flows over a cold, snow-covered surface. The surface cooling increases the stability and may produce fog at night.

The air may be subjected to forced lift in approaching the Appalachians. This upslope flow causes cooling and condensation and may result in the forming of towering cumulus or cumulonimbus clouds with snow showers. On the eastward side of the mountains the air descends and warms adiabatically, causing the clouds to be partially or completely dissipated. (See fig. 14-3.)

Consider how cPk air can become mT air. In winter, when cPk air reaches the warm waters off the southern coast of the United States, its temperature is usually about 10° lower than the water temperature. The air is rather unstable when it reaches the water surface. The same thing happens when the air flows over the Great Lakes, except the Great Lakes are relatively a small area, whereas now the modification occurs over such a large area that a new air mass is formed. Both the temperature and moisture content of the air rapidly increase, beginning in the lower levels and quickly affecting the higher levels. Thus, rapid changes in the weather can be expected as cPk air moves over an mT source region. (See fig. 14-4.)

After mP air crosses the Rocky Mountains and stagnates in the Great Basin, it often becomes cP air. By the same token, cP air moving out over the Atlantic rapidly modifies to become mP air.

In Siberia, cP air is the coldest air mass on record in the Northern Hemisphere; in the Southern Hemisphere this air mass is unknown.

MARITIME POLAR (mP).—Consider the weather associated with maritime polar air (mP). In its source region, maritime polar air, in general, is characterized by surface temperatures above the freezing point, moderately steep lapse rates, and near saturation up to rather high levels. However, since the air aloft is cold, it has a low capacity for water vapor; hence, the water content may be small even though the relative humidity is high. The weather is characterized by cumulus and cumulonimbus clouds with showers and by good visibility except in shower areas.

North America is affected by maritime polar air which comes primarily from a source region in the North Pacific. This air mass usually results from the modification of cold continental air which has moved from Asia or the frozen arctic. The continental air is heated from below and picks up additional moisture as it moves over the ocean, resulting in a characteristically

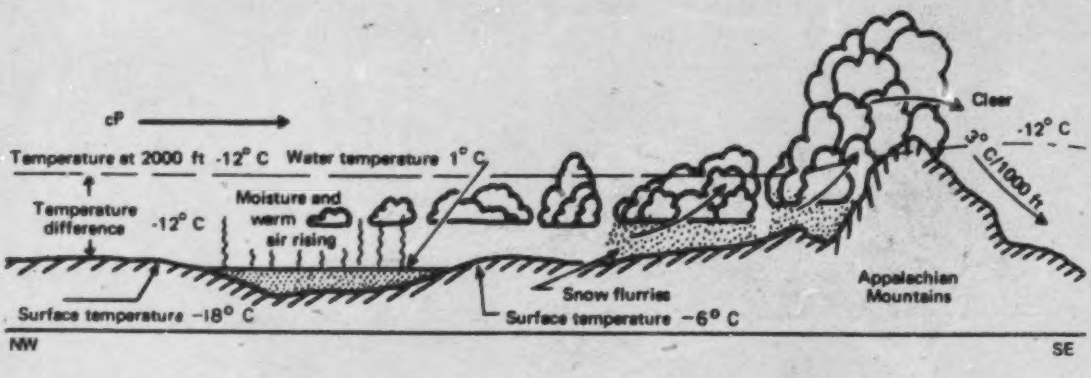

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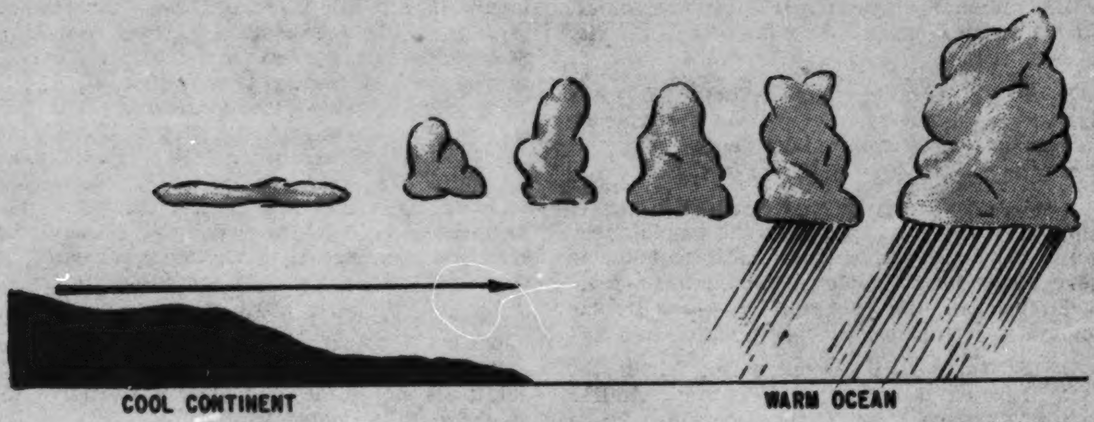
Figure 14-3.—cP air moving over the Great Lakes.

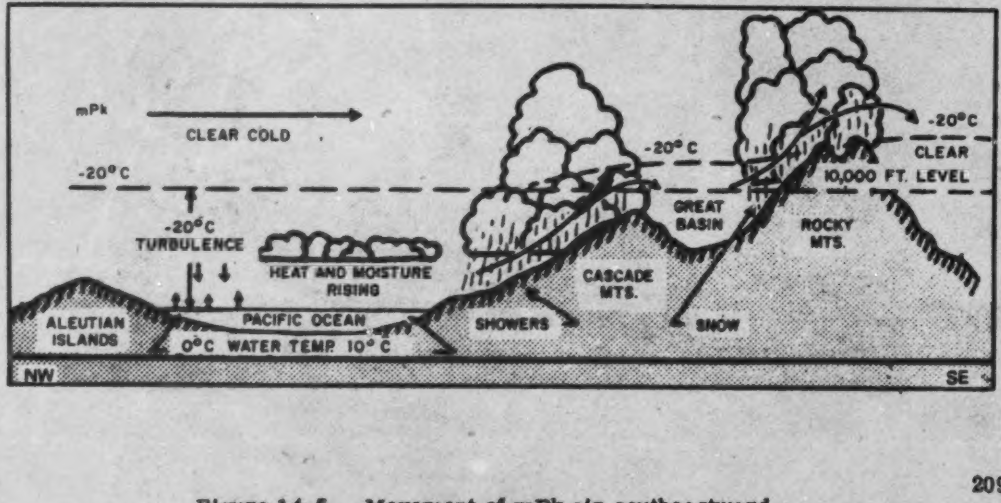

COOL CONTINENT
WARM OCEAN

210.76

Figure 14-4.—When cP air of winter moves from cool continent to warm ocean.

unstable air mass. The convective activity is increased as the air mass is lifted over the mountain ranges along the western coast of the continent. This lifting results in heavy rain and snow showers with considerable turbulence and icing on the windward side of the mountains. (See fig. 14-5.) If the trajectory of the air mass as it moves across the ocean is cyclonic, the instability is increased; if it is anticyclonic, the instability is decreased. Maritime polar air may acquire stable characteristics in its lower levels before reaching the continent if it moves over cold ocean currents after its original modification. When this occurs, it is characterized by stratified clouds, fog, and drizzle.

Maritime polar air of Atlantic origin which occasionally affects the eastern coast of North America differs in two respects from that of


mPk
CLEAR COLD
-20°C
-20°C
TURBULENCE
HEAT AND MOISTURE RISING
ALEUTIAN ISLANDS
PACIFIC OCEAN
0°C WATER TEMP. 10°C
SHOWERS
CASCADE MTS.
-20°C
GREAT BASIN
SNOW
ROCKY MTS.
-20°C
CLEAR
10,000 FT. LEVEL
NW
SE

209.367

Figure 14-5.—Movement of mPk air southeastward.

Pacific origin. Surface temperatures are colder, and the vertical extent of the convective activity is less.

Maritime polar air also affects the south Alaskan coast but seldom reaches the Alaskan interior due to the mountain ranges which it must cross.

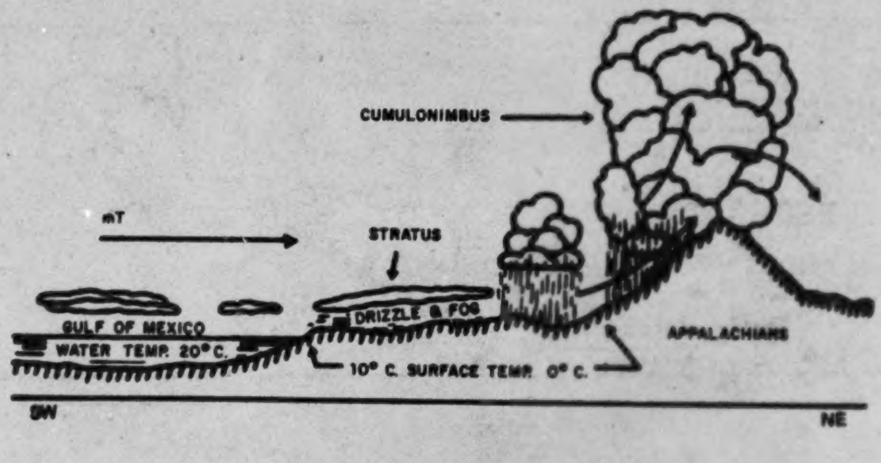
In western Europe, mP air masses predominate. They are quite varied in the weather they cause, depending on whether their trajectories are cyclonic or anticyclonic. The most unstable conditions are the rule with a cyclonic trajectory.

In the Southern Hemisphere, mP air is the most prevalent air mass and is quite similar to its Northern Hemisphere counterpart in characteristics and in the weather it causes.

MARITIME TROPICAL (mT).—The mT air which is formed over the Gulf of Mexico is usually conditionally unstable. This instability may be released by frontal or orographic lifting. When mT air is forced up in the eastern mountains of the United States, practically the same types of weather result as were discussed under the Great Lakes effect. However, the weather associated with the mT air is more intense because of the greater quantity of moisture involved, and extends to a higher level. If mT air is forced over mountainous terrain, as in the eastern part of the United States, the conditional instability of the air is released at higher levels. (See fig. 14-6.) This might produce thunderstorms or at least large cumuliform clouds. These clouds may develop out of stratiform cloud systems and therefore may be encountered without warning when flying within the clouds. Icing may also be present. Thus, as with the Great Lakes effect, a combination of all three hazards (fog, thunderstorms, and icing) is possible.

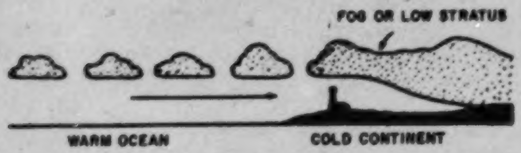
Now consider the weather associated with maritime tropical warm air (mTw) of Atlantic origin. In winter, when the land surface is relatively cold, the mT air moves northward as mTw. It is cooled from below. This cooling results in more stable conditions near the surface. Due to the high moisture content, condensation occurs (either as fog or as low stratus) particularly at night when radiational cooling plays an important part. (See fig. 14-7.) In the lower latitudes, the heating effect of the sun usually causes sufficient convective lift to produce cumuliform clouds in the afternoon.

Maritime tropical air of Pacific origin is quite rare in winter, but it causes torrential rains on those rare occasions when it invades the California coast.



209.368

Figure 14-6.—mT air moving northeastward.



209.369

Figure 14-7.—mT (Gulf or Atlantic) air of winter moving northward over cold continent.

In western and southern Europe, the invasion of mT air brings milder weather than in the United States. Low clouds, fog, and drizzle are the normal results with mT, because the air is usually quite stable. This air mass seldom invades eastern Europe.

Maritime tropical air masses of the Southern Hemisphere are very similar to those of the Northern Hemisphere in both characteristics and weather.

In Asia, mT air is rare. The continent is dominated by the outflow from the Asiatic high which pushes southward over the Himalayas to India and southeast Asia and arrives in a highly modified form (the air of winter monsoon).

CONTINENTAL TROPICAL (cT).—Continental tropical air is entirely absent from the North American Continent in winter. The primary regions with cT air in winter are north Africa and Asia Minor. This air is unstable but quite dry and thus causes little weather, and it does not reach southern Europe in winter.

The only other source of true cT air in winter is the interior of Australia. In the Southern Hemisphere winter, this air is unstable but dry and causes little weather.

SUPERIOR AIR (S).—Superior air is a high-level air mass found over the Southwestern United States. It sometimes reaches the surface; and due to subsidence effects, it is the warmest air mass on record in the North American Continent in both seasons. It is extremely dry and provides cloud-free skies and excellent visibility.

Summer Air Masses

In summer the arctic front retreats to northern Canada and disappears in the arctic over the North American Continent. In Europe and northern Asia, an outbreak of arctic air is rare, and little needs to be said about this air. In the Southern Hemisphere, the arctic air which leaves the Antarctic Continent is rapidly modified to mP and therefore is of little interest to us here.

MARITIME POLAR.—Over the North American Continent, the whole Pacific coast is usually under the influence of mP air. It is much milder in summer than in winter, and seldom extends east of the Rockies. The coastal weather is generally clear with scattered cumulus.

Along the Atlantic coast the occasional influx of mP brings relief from heat waves, but causes little weather.

In Europe, mP air is predominant. It is quite unstable, but usually too dry to cause much shower activity. Maritime polar air is rare in Asia, but in the Southern Hemisphere it is the predominant air mass, encircling the whole Southern Hemisphere.

CONTINENTAL POLAR.—The source region is confined roughly to the northern two-thirds of Canada, but polar air of Canadian origin occasionally invades the United States in summer. When it does, it preserves to a large extent its temperature characteristics. Convective activity in the United States is extensive but mild, confined in height to 700 mb (10,000 ft) or less.

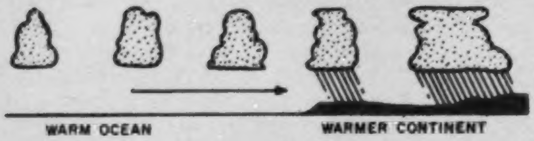
Continental polar air is infrequent over Europe in summer. Occasional invasions of this air come from Russia or the Balkans, and these invasions have a southerly trajectory and, consequently, are warmer than cP to the east; but the weather is relatively stable.

MARITIME TROPICAL.—On the west coast, mT air of Pacific origin has little or no influence on the weather, but on the east coast mT air is the most extensive air mass in summer. The mT air is quite warm and quite moist with a dewpoint near or in excess of 70° F at the surface. Low stratiform clouds are the rule in the mornings, especially along the east coast, becoming convective clouds during the day, with frequent thunderstorms by late afternoon. (See fig. 14-8.) Flying conditions are not hazardous despite the thunderstorms because they are easily circumnavigated. Ground fogs are frequent with northward movement of mT air over land. Sea fogs are frequent with movement over water. The famous fogs of the Grand Banks are typical of mT air over a cold ocean current.

When mT air invades southwestern Europe, the weather is somewhat cooler than in the United States because of the cold ocean currents and the stable anticyclonic circulation. Over water, mT has stratiform low clouds, fog, and drizzle. Over land the air is subject to convection.

Asian mT air originating over the Pacific is usually observed along the coast of China and over the islands of Japan; it is extremely warm, moist, and unstable. Weather conditions encountered in it are similar to its North American counterpart. In summer this air is replaced in southeast Asia with equatorial air, and it is this equatorial air which brings with it the monsoon of that region. Over the western North Pacific great fog banks form in summer in mT air, much in the same manner and for the same reason as do the fog banks over the Grand Banks of the Atlantic coast.

The mT air masses of the Southern Hemisphere are quite similar to their counterparts of the Northern Hemisphere; that is, on the east coast of South America, South Africa, and Australia, the weather is similar to that on the east coast of North America. On the west coast of South America, Australia, and south Africa, the weather is similar to that on the North American west coast.



209.370
Figure 14-8. — mT (Gulf or Atlantic) air of summer moving northward over warm continent.

CONTINENTAL TROPICAL.—This air is found only during summer, forming over a small area of northern Mexico, western Texas, New Mexico, and eastern Arizona. It can be identified by its extremely high surface temperatures, very low humidities, large diurnal temperature ranges, and rare precipitation. Flying conditions are excellent with respect to weather, but clear air turbulence is extensive.

European cT air masses have their source regions in north Africa and Asia Minor. As they move into southern Europe, much moisture is added and instability showers result. In north Africa and Asia Minor, cT air is present all year round. During summer, the north African air mass is the hottest air mass on record in the world. It is extremely warm and dry, but quite unstable.

In the Southern Hemisphere, cT air is found in summer in South America, Australia, and a small area of south Africa (the Kalahari Desert). The South American cT air is usually modified mT air. The south African cT air mass is small and somewhat cooler than either of the other Southern Hemisphere cT air masses. The Australian cT air is similar in all characteristics to the north African cT air mass.

EQUATORIAL AIR.—Equatorial air is the air on either side of the thermal Equator, with the Intertropical convergence zone (ITCZ) separating the Northern and Southern Hemisphere equatorial air. It is warmer than mT air, and more moist at all levels. In India and southeast Asia this air is often referred to as monsoon air. During summer it is characterized by extreme convective activity and heavy showers in both hemispheres.

SUPERIOR.—As was pointed out previously, S air is observed in the Northern Hemisphere both in winter and in summer. The only difference between winter and summer S air is that the temperatures are higher in summer.

PROPERTIES

In studying air masses, it has been determined that the physical properties of an air mass depend upon its life history.

During the life span of an air mass, some of the physical properties, such as the surface air temperature and humidity, are apt to change frequently and rapidly due to lifting, conduction, radiation, evaporation, or some local topographical feature. Some properties of the air mass remain almost constant for a period of time. An element of an air mass that has little change from day to day is considered as being conservative. A nonconservative property is one that changes frequently and rapidly.

Although a strictly conservative property probably does not exist in the atmosphere, there are certain properties that for a short period of time, and under certain conditions, are so nearly constant that they may be considered as conservative.

The most important physical properties in air masses are those that concern temperature and moisture. The various expressions of temperature and moisture are summarized in table 14-2. The Aerographer's Mate should learn the significance of the various properties listed in this table.

Since many nonadiabatic processes occur near the surface of the earth, it becomes necessary to study the adiabatic conditions of the upper atmosphere in classifying an air mass. Some authorities differ as to the properties to use in air-mass identification. However, from table 14-2 it can be seen that the equivalent potential temperature and the potential wet-bulb temperature are conservative relative to both dry adiabatic and moist adiabatic temperature changes, while other elements are conservative in regard to only one type or nonconservative in regard to both types of temperature change.

In order to understand table 14-2 better, it is imperative that the Aerographer's Mate learn the definitions of the various properties listed in that table. Temperature, relative humidity, dewpoint, and mixing ratio were

Table 14-2. — Conservative characteristics of the physical properties of air masses with respect to adiabatic temperature changes

Property	Conservative with respect to	
	Dry adiabatic temperature changes	Moist adiabatic temperature changes
Temperature	No	No
Relative humidity	No	Yes
Dewpoint temperature*	Quasi-conservative	No
Wet-bulb temperature	No	No
Mixing ratio*	Yes	No
Potential temperature	Yes	No
Equivalent temperature	No	No
Equivalent potential temperature	Yes	Yes
Potential wet-bulb temperature.	Yes	Yes

*These two properties are conservative with respect to nonadiabatic temperature changes; therefore it is advantageous to use these elements in the analysis of surface weather charts.

defined and explained in chapter 12, while the remaining terms were defined in chapter 10, under the section on the SKEW-T Diagram.

FRONTS

Since most major changes of the weather are associated with fronts, it is essential for the Aerographer's Mate to become thoroughly familiar with them. This requires that he understand the relationship of fronts to cyclones and air masses, and the characteristics of, and the weather associated with, the various types of fronts. He must also know the relationship between fronts and pressure systems. Finally, he must become adept at following frontal movements and anticipating their speeds and the modifications which they undergo along the way.

RELATION OF FRONTS TO AIR MASSES

The descriptive term "front" is defined as a boundary, or line of discontinuity, separating two different air masses. From the definition, the close relationship that exists between air masses and fronts can be readily seen. In fact, without the air masses there would be no fronts.

The centers of action bring together air masses of different physical properties. The region of transition between two air masses is called a frontal zone. The primary frontal zones of the Northern Hemisphere are the Arctic frontal zone and the polar frontal zone. The most important frontal zone affecting the United States is the polar front. The polar front is the region of transition between the cold polar air and warm tropical air. During the winter months (in the Northern Hemisphere), the polar front pushes far southward due to the greater density of the polar air than during the summer months. During the summer months (in the Northern Hemisphere), the polar front seldom moves farther south than the Central United States.

On a surface map a front is indicated by a line separating two air masses; this is only a picture of the surface conditions. These air masses also have vertical extent. (See fig. 14-9.)

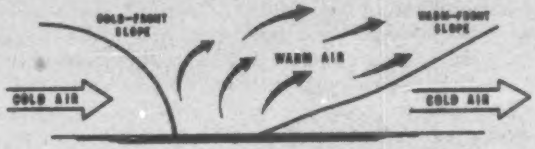


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Figure 14-9.—Vertical view of a frontal system (without clouds shown).

A cold air mass, being heavier, tends to underrun a warm air mass. Thus, the cold air is below and the warm air is above the surface of discontinuity. The slope of a frontal surface is usually between 1 to 50 (1 mile vertical for 50 miles horizontal) for a cold front and 1 to 300 (1 mile vertical for 300 miles horizontal) for a warm front. For example, 100 miles from the place where the frontal surface meets the ground, the frontal surface might be somewhere between 2,000 feet and 2 miles above the earth's surface, depending on the slope. The slope of a front is of considerable importance in visualizing and understanding the weather along the front. In general, all the cross sections of fronts as shown in this chapter summarize pictorially all the pertinent features of all types of fronts under average conditions.

Cold Fronts

A cold front is the line of discontinuity along which a wedge of cold air is underrunning and displacing a warmer air mass. This term is also used, but inexactly, when referring to a cold frontal surface.

There are certain weather characteristics and conditions that are typical of cold fronts. In general, the temperature and humidity decrease, the pressure rises, and in the Northern Hemisphere the wind shifts (usually from southwest to northwest) with the passage of a cold front. The distribution and type of cloudiness and the intensity and distribution of precipitation depend primarily on the vertical velocities in the warm air mass. On the basis of this latter factor, cold fronts are classified as slow-moving and fast-moving cold fronts.

SLOW-MOVING COLD FRONT.—With the slow-moving cold front there is a general upward motion of warm air along the entire frontal surface except for pronounced lifting along the lower portion of the front. The average slope of the front is approximately 1:100 miles. The cloud and precipitation area is extensive and is characterized by cumulonimbus and nimbostratus clouds, showers, and thunderstorms at, and immediately to the rear of, the surface front. This area is followed by a region of rain and nimbostratus clouds merging into a region of altostratus clouds and then cirrostratus clouds, which may extend several hundred miles behind the surface front.

The development of cumulonimbus clouds, showers, and thunderstorms is largely dependent on the original instability characteristics of the warm air mass. Within the cold air mass there may be some stratified clouds in the rain area, but there are no clouds in the cold air beyond this area unless the cold air mass is unstable. In the latter case, some cumulus clouds may develop. This type of front is slow moving; 15 knots may be considered average. See figure 14-10 for a cross section through a typical slow-moving cold front.

FAST-MOVING COLD FRONTS.—With the fast-moving cold front there is descending motion of the warm air along the frontal surface at high levels, and the warm air near the surface is pushed vigorously upward. This type of front has a slope of 1:40 to 1:80 miles and usually moves rapidly; 25 to 30 knots may be considered as an average speed of movement. As a result of these factors, there is a relatively narrow but often violent band of weather. If the warm air mass is conditionally unstable and moist, cumulonimbus clouds, showers, and thunderstorms occur just ahead of and at the surface front, and rapid clearing occurs behind the front. Frequently, altostratus and altocumulus cloud layers form and drift ahead of the main cloud bank. The more unstable the warm air mass, the more violent the weather. If the warm air is relatively dry, this type of front may not produce precipitation or clouds. It is with the fast-moving cold front that squall lines are associated.

Figure 14-11 shows a typical cross section through a fast-moving cold front; it also shows the cloud shield, precipitation shield, and frontal slope (exaggerated in the vertical) associated with this type of front.

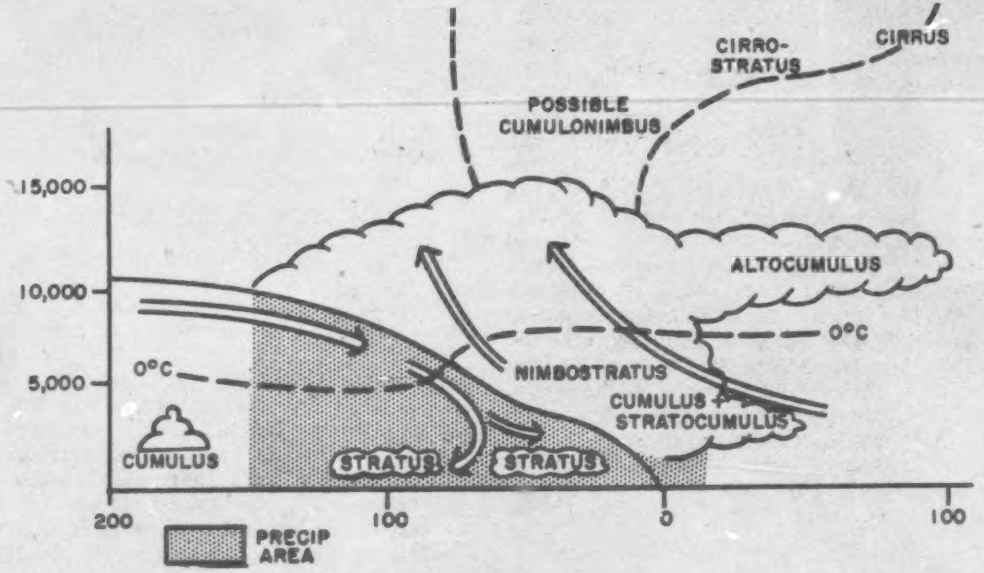

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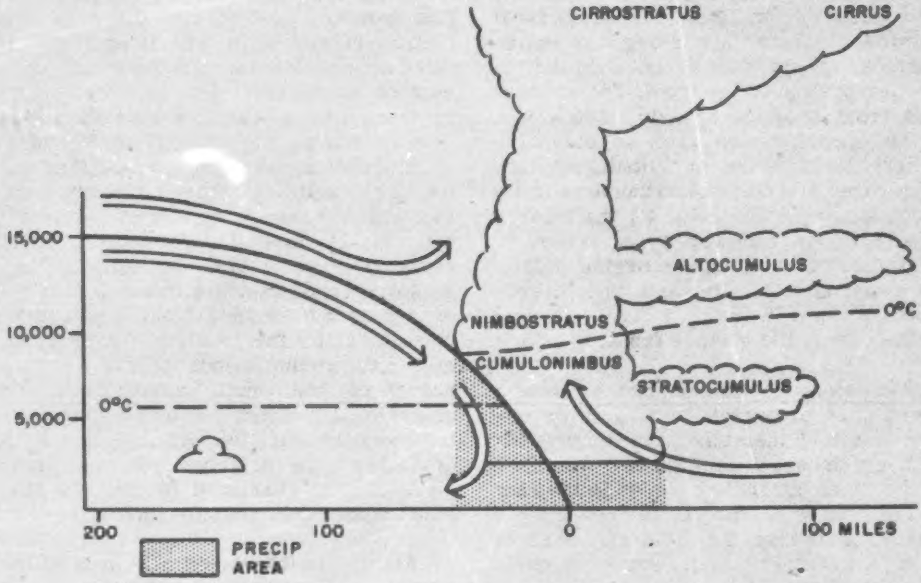
Figure 4-10.—Vertical cross section of a slow-moving cold front.



209.60

Figure 4-11.— Vertical cross section of a fast-moving cold front.

Warm Fronts

A warm front is the line of discontinuity where the forward edge of an advancing mass of relatively warm air is replacing a retreating relatively colder air mass. As in the case of the cold front, this term is used inexactly when referring to a warm frontal surface.

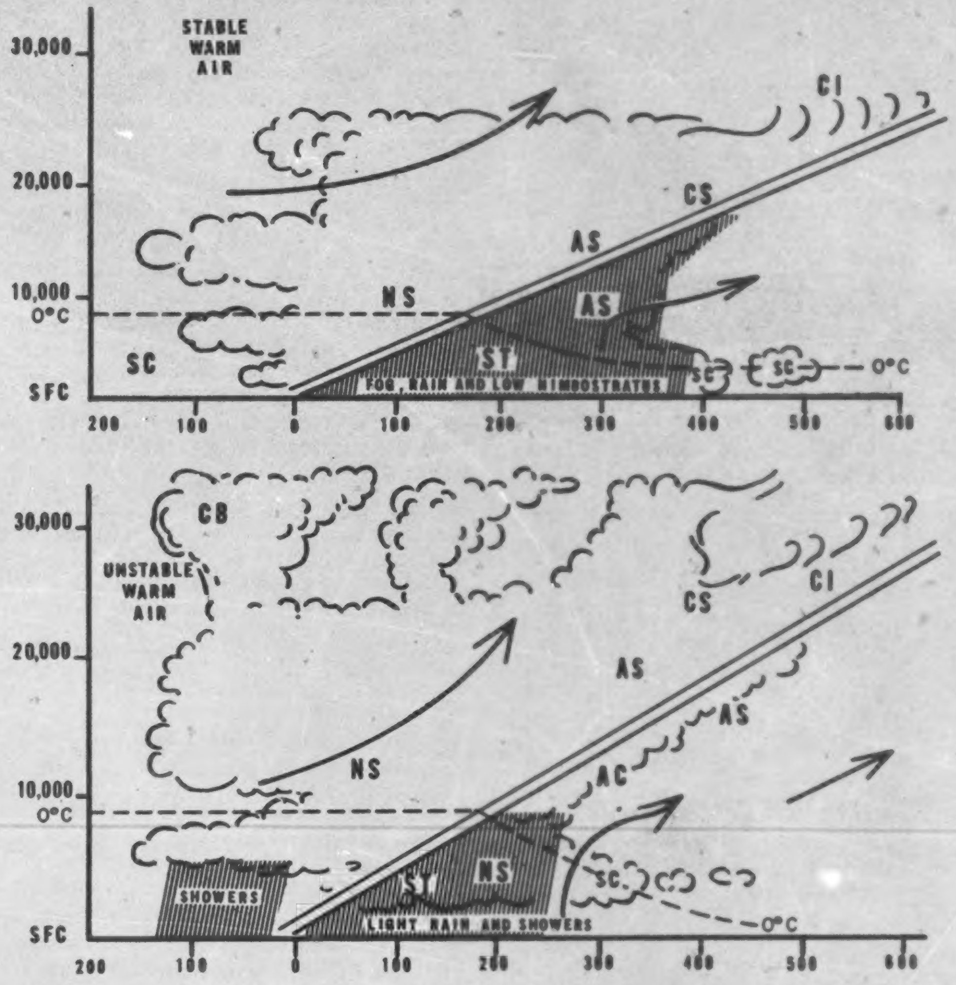
Certain characteristics and weather conditions are associated with warm fronts. The winds shift from southeast to southwest or west, but the shift is not as pronounced as with the cold front. The temperatures are colder ahead of the front and are warmer after the passage of the front. Not being greatly affected by daily heating and cooling of the earth's surface, the dewpoint is normally more constant than the temperature through the day except with the passage of a front. Therefore, the dewpoint is a good index of frontal passage. The average slope of a warm front is 1:150.

A characteristic phenomenon of a typical warm front is the sequence of cloud formations. They are noticeable in the following order: Cirrus, cirrostratus, altostratus, nimbostratus, and stratus. The cirrus clouds may appear 700 to 1,000 miles ahead of the surface front followed by cirrostratus about 600 miles and altostratus about 500 miles ahead of the surface front.

Precipitation in the form of continuous or intermittent rain, snow, or drizzle is frequent as much as 300 miles in advance of the surface front. Surface precipitation is associated with the nimbostratus in the warm air above the frontal surface and from stratus in the cold air. However, when the warm air is convectively unstable, showers and thunderstorms may occur in addition to the steady precipitation. Fog is common in the cold air ahead of a warm front.

Clearing usually occurs after the passage of a warm front, but under some conditions drizzle and fog may occur within the warm sector. Warm fronts usually move in the direction of the isobars of the warm sector; in the Northern Hemisphere this is usually east to northeast. Their speed of movement is normally less than that of cold fronts; on the average it may be considered to be about 10 knots.

Figure 14-12 summarizes pictorially the pertinent features of warm fronts under average conditions.


STABLE WARM AIR
30,000
20,000
10,000
0°C
SFC
SC
NS
AS
CS
CI
AS
ST
FOG, RAIN AND LOW NIMBOSTRATUS
SC
SC
0°C
200
100
0
100
200
300
400
500
600
CB
UNSTABLE WARM AIR
30,000
20,000
10,000
0°C
SFC
CS
CI
AS
AS
NS
AC
SHOWERS
ST
NS
SC
LIGHT RAIN AND SHOWERS
0°C
200
100
0
100
200
300
400
500
600

201.57

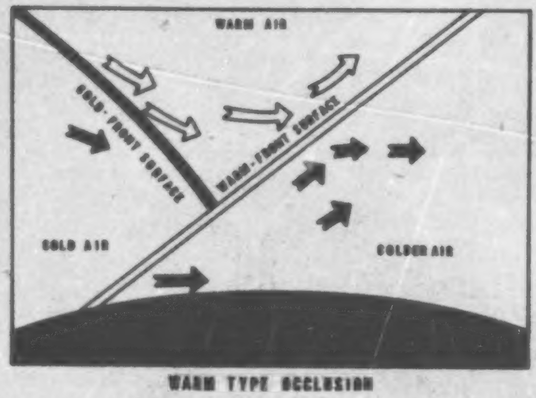
Figure 14-12.—Vertical cross section of a warm front.

Occluded Fronts

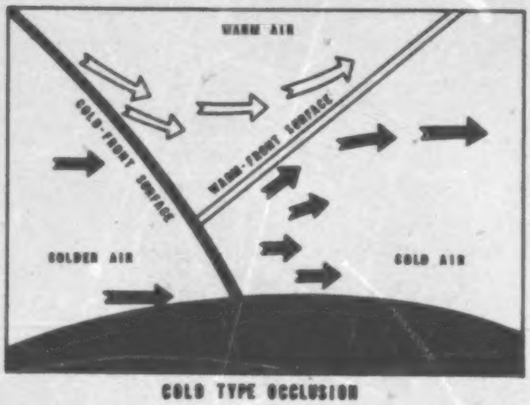
An occluded front occurs when a cold front overtakes a warm front. One of the two fronts is lifted aloft, and the warm air between the fronts is shut off from the earth's surface. An occluded front is often referred to as an occlusion. The type of occlusion is determined by the temperature difference between the cold air in advance of the warm front and the cold air behind the cold front.

WARM TYPE OCCLUSION.—If the air in advance of the warm front is colder than the air behind the cold front, the cold front rides up the warm frontal slope. (See fig. 14-13.)

COLD TYPE OCCLUSION.—If the cold air ahead of the warm front is warmer than the cold air behind the cold front, the cold frontal surface underruns the warm front and the occluded front is called a cold type occlusion. (See fig. 14-14.)



201.58.1
Figure 14-13.—Vertical cross section of a warm type occlusion.



201.58.2
Figure 14-14.—Vertical cross section of a cold type occlusion.

The primary difference between a warm type and cold type occlusion is the location of the associated upper front in relation to the surface front. (See fig. 14-15.) In a warm type occlusion the upper cold front precedes the surface occluded front by as much as 200 miles. In the cold type occlusion the upper warm front follows the surface occluded front by 20 to 50 miles.

Since the occluded front is a combination of a cold front and a warm front, the resulting weather is that of the cold front's narrow band of violent weather and the warm front's widespread area of cloudiness and precipitation occurring in combination along the occluded front. The most violent weather occurs at the tip of the occlusion. (The tip is the point at which the cold front is overtaking the warm front.)

Stationary Fronts

When a front is stationary, the cold air mass, as a whole, does not move either toward or away from the front. In terms of wind direction, this means that the wind above the friction layer blows neither toward nor away from the front, but parallel to it. It follows that the isobars, too, are nearly parallel to a stationary front. This characteristic makes it easy to recognize a stationary front on a weather map.

The frictional inflow of warm air toward a stationary front causes a slow upglide of air on the frontal surface. As the air is lifted to and beyond its lifting condensation level, clouds form in the warm air above the front.

If the warm air in a stationary front is stable, the clouds are stratiform. Drizzle may then fall; and as the air is lifted beyond the freezing level, icing conditions develop and light rain or snow may fall. At very high levels, above the front, ice clouds are present. (See fig. 14-16.)

If the warm air is conditionally unstable and sufficient lifting occurs, the clouds are then cumuliform or stratiform with cumuliform protuberances. If the energy release is great (warm, moist, unstable air), thunderstorms result. Rainfall is generally showery.

Within the cold air mass extensive fog and low ceiling may result, where the cold air is saturated by warm rain or drizzle falling through it from the warm air mass above. If the temperature is below 0° C, icing may occur, but generally it is light. (See fig. 14-17.)

The width of the band of precipitation and low ceiling varies from 50 miles to about 200 miles, depending upon the slope of the front and the temperatures of the air masses. One of the most annoying characteristics of a stationary front is that it may greatly hamper and delay air operations by persisting in the area for several days.

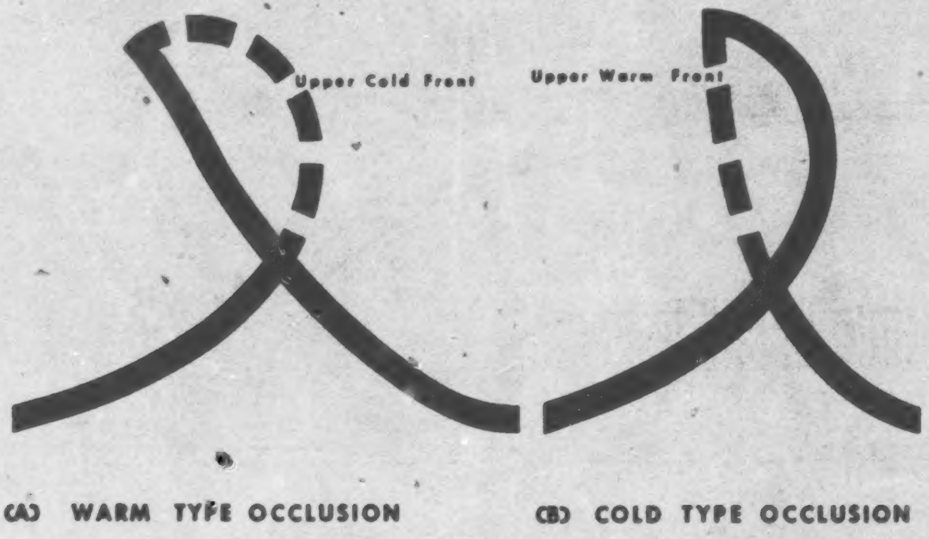

Upper Cold Front
Upper Warm Front
(A) WARM TYPE OCCLUSION
(B) COLD TYPE OCCLUSION

Figure 14-15.—Sketch of occlusions (in the horizontal) and associated upper fronts. 209.64

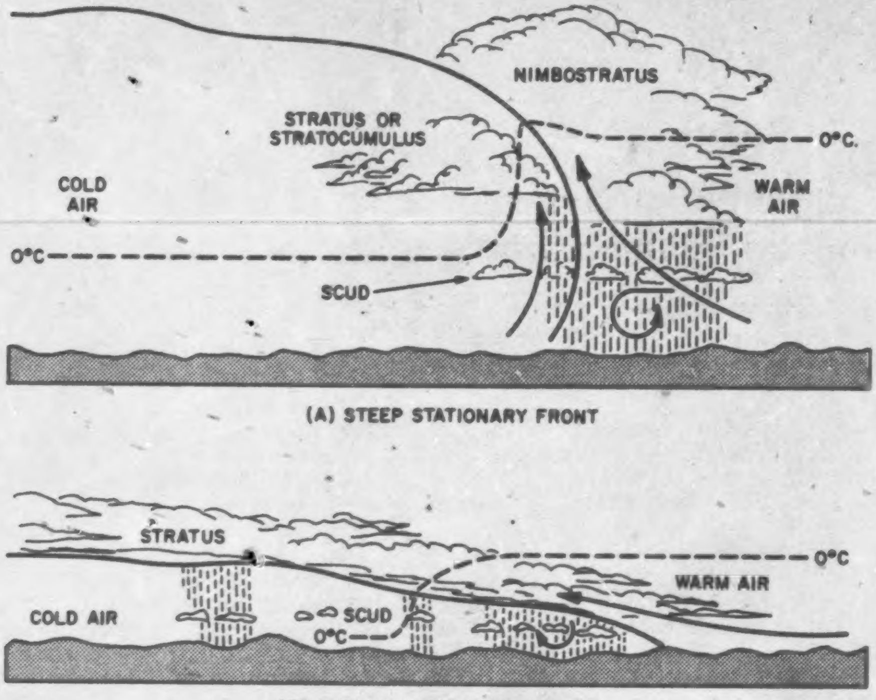
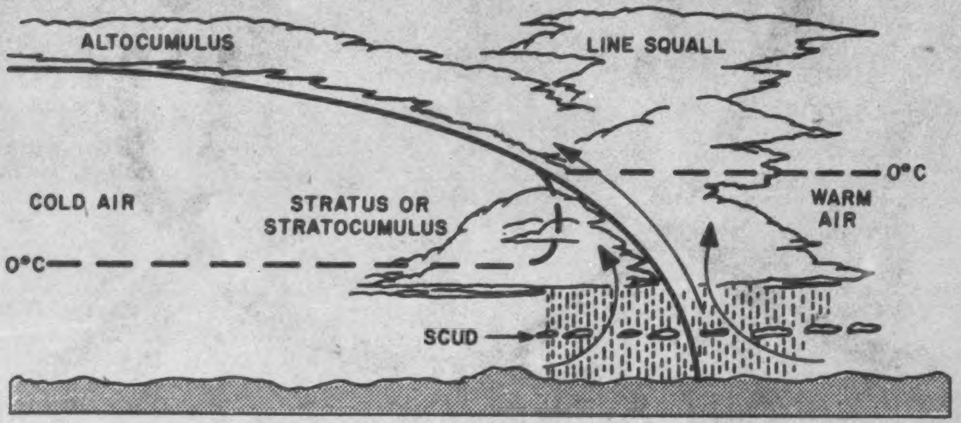
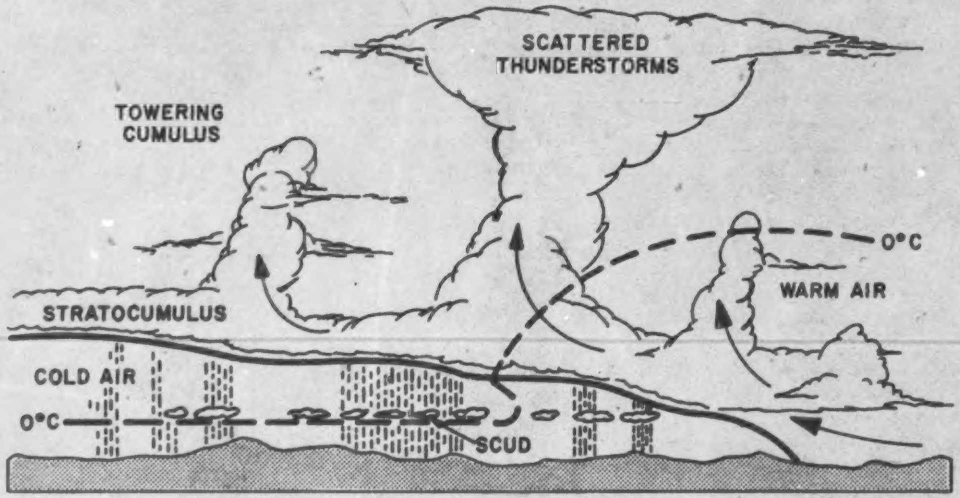

NIMBOSTRATUS
STRATUS OR STRATOCUMULUS
0°C.
COLD AIR
WARM AIR
0°C
SCUD
(A) STEEP STATIONARY FRONT
STRATUS
0°C
WARM AIR
COLD AIR
SCUD
0°C
(B) SHALLOW STATIONARY FRONT

Figure 14-16.—Types of stable stationary fronts. 209.371


ALTOCUMULUS
LINE SQUALL
0°C
COLD AIR
STRATUS OR STRATOCUMULUS
WARM AIR
0°C
SCUD

(A) STEEP STATIONARY FRONT


SCATTERED THUNDERSTORMS
TOWERING CUMULUS
0°C
WARM AIR
STRATOCUMULUS
COLD AIR
0°C
SCUD

(B) SHALLOW STATIONARY FRONT

209.372

Figure 14-17.—Types of unstable stationary fronts.

PRESSURE AT FRONTS

One of the important characteristics of all fronts is that on both sides of a front the pressure is higher than at the front. This is true even though one of the air masses is relatively warm and the other is relatively cold. Fronts are associated with troughs of low pressure. (A trough is defined as an elongated area of relatively low pressure.) A trough may have U-shaped or V-shaped isobars.

Friction causes the air near the ground to drift across the isobars toward lower pressure. This causes a drift of air toward the front from both sides. Since the air cannot disappear into the ground, it must move upward. Hence, there is always a net movement of air upward in the region of a front. This is another important characteristic of fronts, since the lifting of the air causes condensation, clouds, and weather. While air motion within an area of high pressure is downward and outward, motion in a frontal zone is inward and upward. (This is the divergence and convergence, respectively, mentioned in chapter 13.)

RELATION OF FRONTS TO CYCLONES

Every front is associated with a cyclone in a systematic way. The cyclone is a counterclockwise circulation (in the Northern Hemisphere) around a central low-pressure area, about which the fronts move. Cyclones contribute to and partly control frontal movements, but the reverse is not true.

When some temperature, pressure, or wind irregularity occurs along a front, cyclonic circulation may take place. The front will wave forming a cold front and a warm front which will move with the cyclonic circulation. If the fronts are moving at equal speeds, the wave remains stable and moves along the front, either weakening and disappearing, or it becomes absorbed in some large circulation. If the cold front moves faster than the warm front in the cyclonic circulation, it will overtake the warm front and occlude. After it has occluded, the cyclonic circulation and time have changed the original air masses through mixing them and making them so similar that the occluded front loses its identity and dissipates, leaving the remains of the original front well away from the decaying cyclonic circulation. (See fig. 14-18.)

When the polar front moves southward, it is usually associated with the development and movement of cyclones and with outbreaks of cold polar air. The cyclonic circulation associated with the polar front tends to bring polar air southward and warm moist tropical air northward.

During the winter months, the warm airflow usually occurs over water, and the cold air moves southward over continental areas. In summer the situation is reversed.

Large cyclones that form on the polar front are usually followed by smaller cyclones and are referred to as families. These smaller cyclones tend to carry the front farther southward.

In an ideal situation these cyclones come in succession, causing the front (in the Northern Hemisphere) to lie in a southwest to northeast direction.

Every moving cyclone usually has two significant lines of convergence distinguished by thermal properties. The discontinuity line on the forward side of the cyclone where warm air replaces cold air is the warm front; the discontinuity line in the rear portion of the cyclone where cold air displaces warm air is the cold front.

In figure 14-18 the wave development and formation of a cyclone shows the frontal systems which are present throughout the different stages.

Anticyclones are usually coexistent with areas of good weather. This is due mainly to divergence. However, frontal systems may at times penetrate the anticyclones to some extent.

FRONTAL MOVEMENT

The weather is greatly affected by the movement of frontal systems. From the time the front develops until it passes out of the weather picture, it is watched closely. The speed at which it travels and the modifications which it undergoes are important considerations in analyzing and forecasting the weather.

Speed

The speed of the movement of frontal systems is an important determining factor of weather conditions. Rapidly moving fronts usually cause more severe weather than slower moving fronts. For example, fast-moving cold fronts often cause severe prefrontal squall lines which are extremely hazardous to flying. The fast-moving front does have the advantage of moving across the area rapidly, permitting the particular locality to enjoy a quick return of good weather. Slow-moving fronts, on the other hand, may cause extended periods of unfavorable weather. A stationary front which may

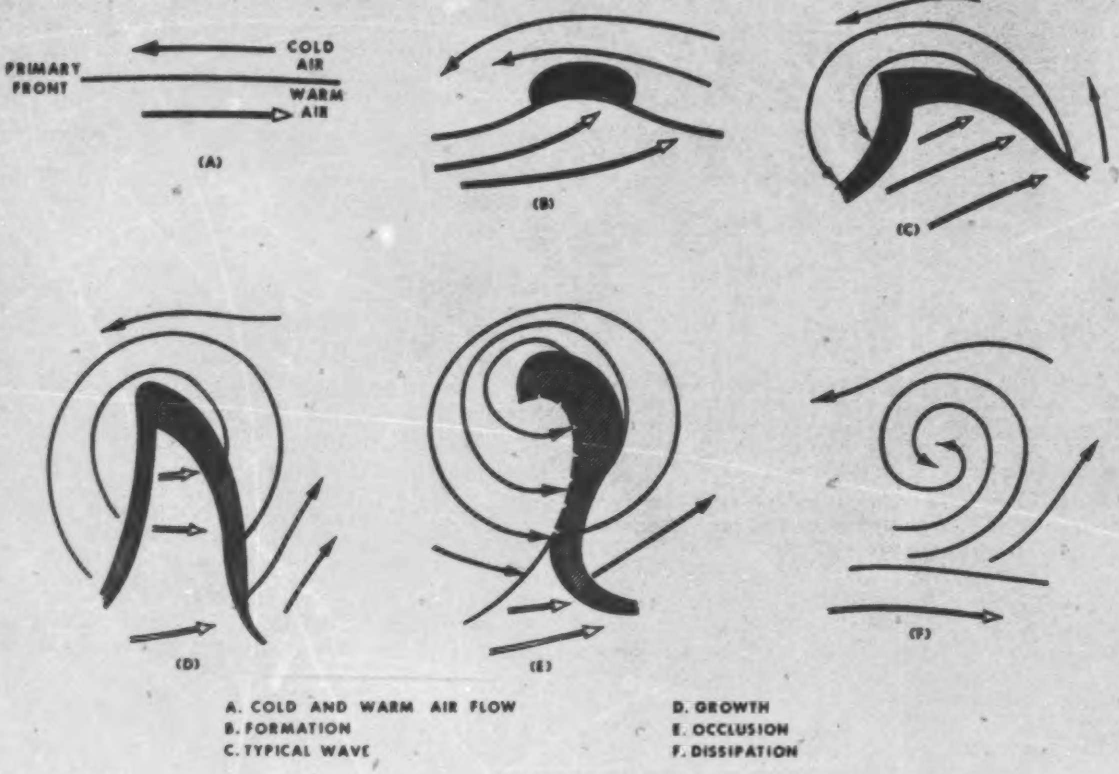


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Figure 14-18.—Life cycle of a wave cyclone.

bring bad weather can disrupt flight operations for several days in succession.

Knowledge of the speed of the frontal system is necessary for accurate forecasting. If the front has a somewhat constant speed, it makes the forecaster's job comparatively easy. However, if the speed is erratic or unpredictable, the forecaster may err as far as time and severity are concerned. His forecast may never materialize in cases in which the front becomes stationary and dissipates without passing over the forecaster's area.

Modifications

There are many factors that can modify the movement of frontal systems. In this section only a few of the more important factors are considered.

EFFECT OF MOUNTAINS.—Mountain ranges affect the speed, the slope, and the weather associated with a front. The height and horizontal distance of the mountain range, along with the angle of the front along the mountain range, are the influencing factors. The effect of mountain ranges differs in regard to cold fronts and warm fronts.

As a COLD FRONT approaches a mountain range, the lower portion of the front is retarded as the upper portion pushes up and over the mountain. On the windward side of the mountain, precipitation is increased due to the additional lift as the warm air is pushed up along the mountain slope. After the front reaches the crest of the mountain, the air behind the front commences to flow down the leeward side of the range. If the air on the leeward side of the mountain is warmer than the air in the rear of the cold front, the warmer air is forced away and replaced by the colder air mass. As the cold air descends the lee side of the mountain, the air warms adiabatically (fig. 14-19) and clearing occurs within it. However, since the cold air is displacing warm air, typical cold frontal clouds and precipitation may occur within the warm air if the warm air is sufficiently moist and conditionally unstable. In some cases maritime polar air which has crossed the Rockies is less dense than maritime tropical air from the Gulf of Mexico which may lie just east of the mountains. If the maritime polar air is moving with a strong westerly wind current and the maritime tropical air is moving with a strong southerly wind current, the maritime polar air may overrun the maritime tropical air. This results in extremely heavy showers and violent thunderstorms and is one of the conditions under which tornadoes occur.

If colder stagnant air lies to the lee side of the mountain range, the cold front on passing over the range does not reach the surface and travels as an upper cold front. Under this condition frontal activity is at a minimum. This situation does not continue indefinitely; either the stagnant air mixes with the air above and the surface of separation becomes spread out, or the upper cold front breaks through to the ground with the development of thunderstorms and squalls.

As a cold front passes a mountain range, it may develop a bulge or a wave as a portion of the front is retarded. In the case of an occlusion, a new and separate cyclone circulation may occur at the peak of the warm sector as the occluded front is retarded by a mountain range.

In general, it may be said that the area of precipitation is widened as the front approaches the range and that there is increased intensity of the precipitation area and cloud system on the windward side of the range and a decrease on the leeward side. (See fig. 14-20.)

Consider the effect of a mountain range on a WARM FRONT. When a warm front approaches a mountain range, the upper section of the frontal surface is above the effects of the mountain range and does not come under

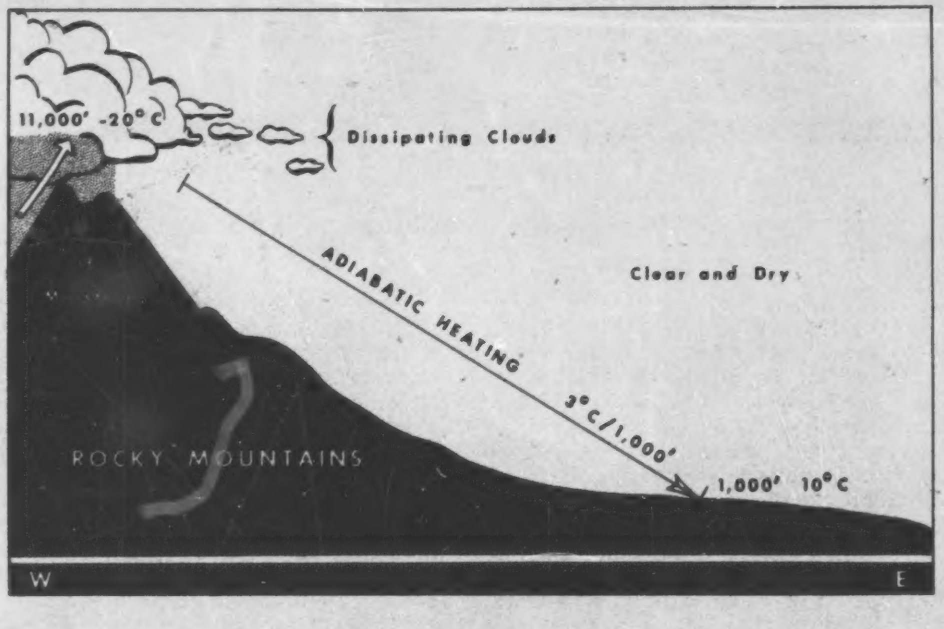

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Figure 14-19.—Effect of adiabatic heating.

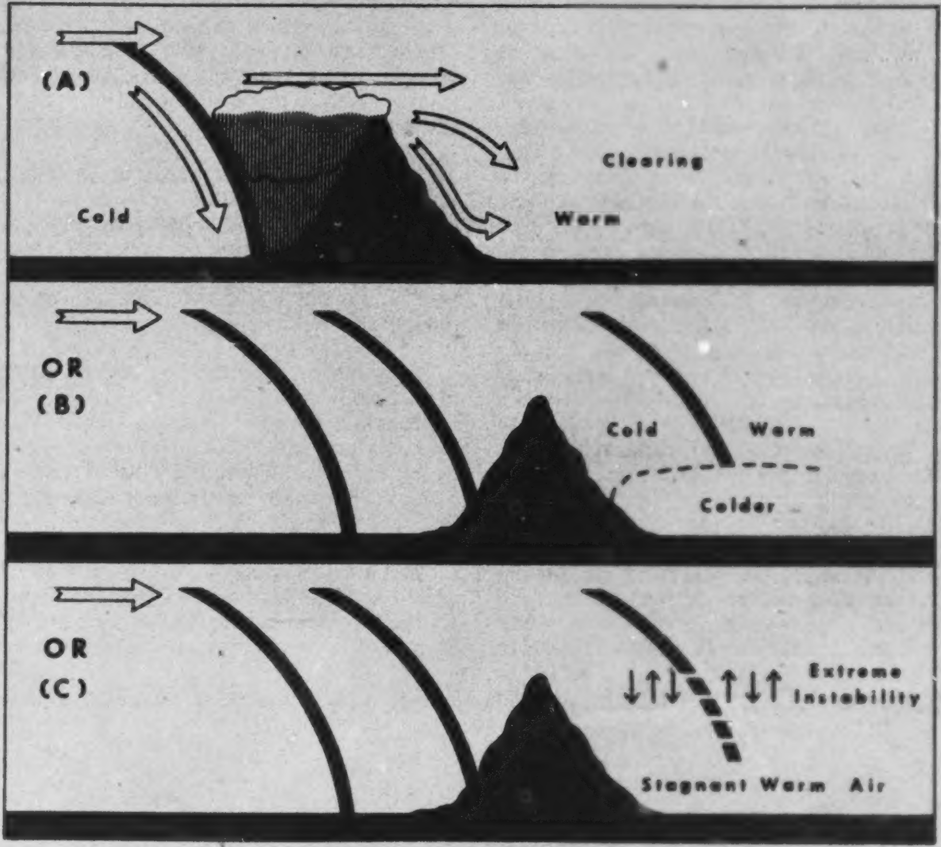

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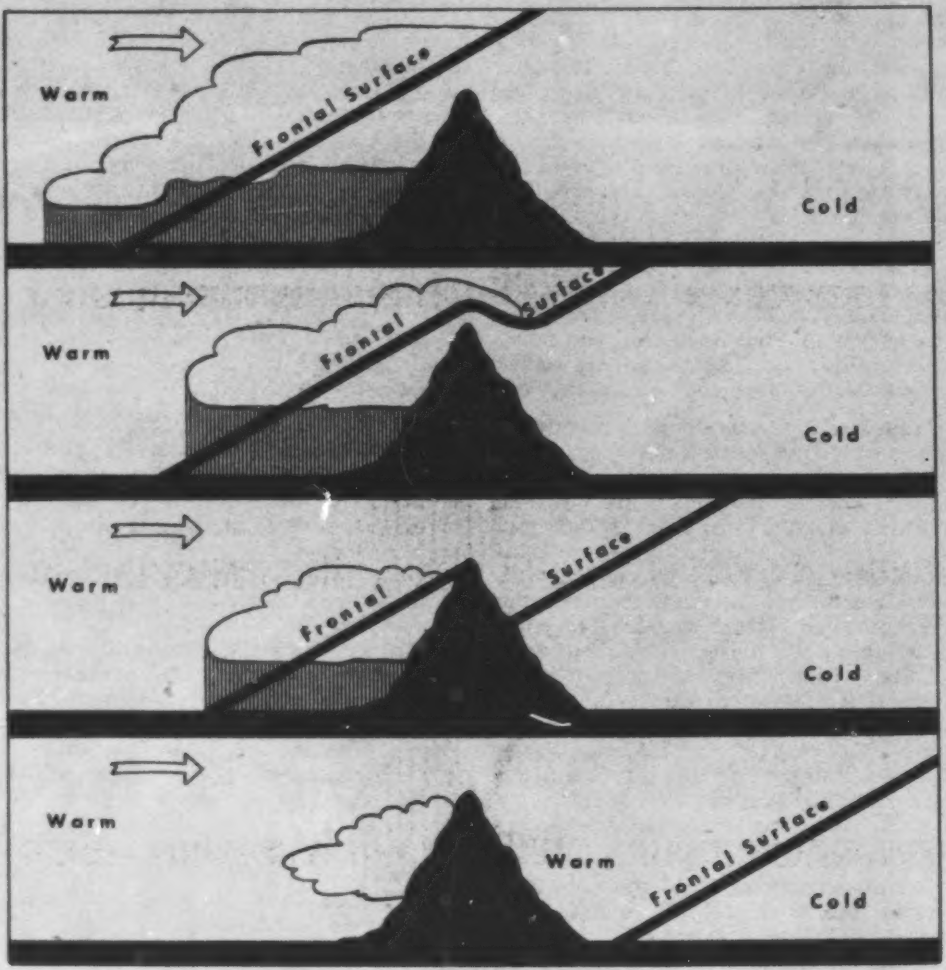
Figure 14-20.— Effect of mountains on a cold front.

its influence. As the lower portion of the frontal surface approaches the range, the underlying cold wedge is cut off, forming a more or less stationary front on the windward side of the range. The inclination of the frontal surface above the range decreases and becomes more horizontal near the mountain surfaces, but the frontal surface maintains its original slope at higher altitudes. While the stationary front on the windward side of the range may be accompanied by prolonged precipitation, the absence of ascending air on the leeward side of the range causes little or no precipitation. The warm air descending the leeward side of the range causes the cloud system to dissipate and the warm front to travel as an upper front.

Frontogenesis (the formation of a new front or the regeneration of an old front) may occur in the pressure-trough area that accompanies the front. The frontal surface then gradually forms downward as the frontal system moves away from the mountain, and it extends to the earth's surface again.

Therefore, the effect of the mountain range on a warm front is to widen and prolong the precipitation on the windward side of the range, while on the leeward side the precipitation band is narrowed and weakened, or dissolved. (See fig. 14-21.)

Mountain ranges have much the same effect on OCCLUDED FRONTS as they do on warm and cold fronts. Cold type occlusions behave


Warm
Frontal Surface
Cold
Warm
Frontal
Surface
Cold
Warm
Frontal
Surface
Cold
Warm
Warm
Frontal Surface
Cold

209.68

Figure 14-21.—Effect of mountains on a warm front.

as cold fronts, and warm type occlusions behave as warm fronts. The occlusion process is accelerated when an open wave approaches a mountain range because the warm front is retarded while the cold front continues its normal movement until it reaches the mountain range.

EFFECT OF OCEAN CURRENTS.—Ocean currents have a modifying effect on frontal movement. To understand why ocean currents have such an effect, it is necessary to consider the movement of the currents.

In middle latitudes, ocean currents carry warm water away from the Equator along the eastern coasts of continents, and carry cold water toward the Equator along the western coasts of continents. The most active frontal zones of the winter season are found where cold continental air moves over warm water off eastern coasts. This situation is noticeable over the Atlantic Ocean off the east coast of the United States. As a cold front moves off the coast and over the Gulf Stream, it becomes intensified, causing wave development to occur near the Cape Hatteras area. This gives the east coast of the United States much cloudiness and precipitation. A similar situation occurs off the east coast of Japan. That area in the Pacific generates more cyclones than any other area in the world.

OTHER EFFECTS.—The movement of a frontal system from one area to another often has a great modifying effect, causing the front to be regenerated in some instances and to be dissipated in others. Transition affects waves and cyclones as well as fronts.

When dissipating, extratropical cyclones enter regions of frontogenesis and cyclogenesis, they are frequently regenerated into active disturbances. This is usually caused by an influx of warm moist air to the east and cold air to the west of the center. In a situation in which a well-defined cyclone, associated with a front (or fronts), moves eastward over the Rocky Mountains, the frontal system is usually weakened by the time it descends the eastern slopes. If there is an influx of warmer moist air from the Gulf of Mexico, the frontal system is regenerated as it moves eastward. If the circulation to the east of the mountain range is such that no moist air is drawn into the cyclone or frontal system, frontolysis (the process of a front weakening or dissolving) takes place.

Frontal systems moving from water to land areas tend to weaken if an influx of moist air is not brought into the situation. On the other hand, a frontal system moving from land areas to water areas is generally regenerated by the influx of moist air. For example, a frontal system may become quasi-stationary in the vicinity of the east coast of the United States. This frontal system is usually oriented in a northeast-southwest direction and occurs mostly during the summer and autumn months, when outbreaks of cP air move southeastward over the States. These fronts usually lose their intensity over the Southern United States and movement ceases. Frequently, stable waves develop and travel along this frontal system, causing unfavorable weather conditions. When these waves move out to sea and warmer moist air is brought into them, they become unstable waves and are intensified as they move across the ocean.

TROPICAL SYSTEMS

Phenomena to be discussed in this section of the chapter will be the tropical systems that have no mid-latitude characteristics, such as the tropical wave, intertropical convergence zone, and tropical cyclones. For a more detailed discussion of these systems and other tropical phenomena, the AG should refer to AWS Technical Report 240.

TROPICAL WAVES

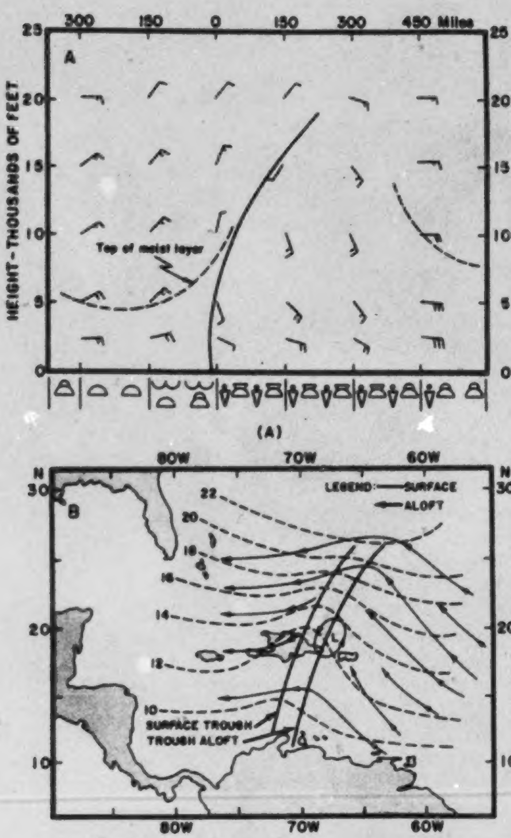
A tropical wave, which in past years has been referred to as an "Easterly Wave", is defined as a trough or a cyclonic curvature maximum located in the easterly trade winds.

Synoptic models for the tropics are not as clear-cut as for mid-latitudes because data on which to base them have been very sparse until the advent of meteorological satellites and high-level jet aircraft. Three models for tropical waves in the Atlantic are given in succeeding paragraphs.

The oldest of the models describes a wave-like pattern in the easterly current of the lower troposphere which moves westward with an average speed of 10 to 15 knots. These waves reach a maximum intensity between 700 to 500 mb and have an eastward slope with height. In the model case, the wave moves slower than the basic lower level currents and faster than the basic upper level currents. This results in subsidence west of the wave trough and convergence as well as disturbed weather east of the wave trough. Figure 14-22 shows the basic tropical wave model in the vertical and horizontal.

In another model, tropical waves move to the west faster than the basic current. This type causes convergence west of its axis and is stronger at the axis with a varied cloud pattern of cumuloform and cumulonimbus west of the wave axis, with a dominant nimbostratus cloud layer east of the axis.

Another tropical wave model is the "Inverted-V" formation. Its name is associated with the herringbone arrangement of the cloud bands associated with it. (See fig. 14-23.) This type is best defined in the eastern and central North Atlantic where it shows good day-to-day continuity and moves about the speed of the low-level trades which is 16 knots.


300
150
0
150
300
450 Miles
A
HEIGHT-THOUSANDS OF FEET
25
20
15
10
5
0
Top of moist layer
80W
70W
60W
N
30
20
10
B
LEGEND: SURFACE
ALOFT
22
20
18
16
14
12
10
SURFACE TROUGH
TROUGH ALOFT

(A)

(B)

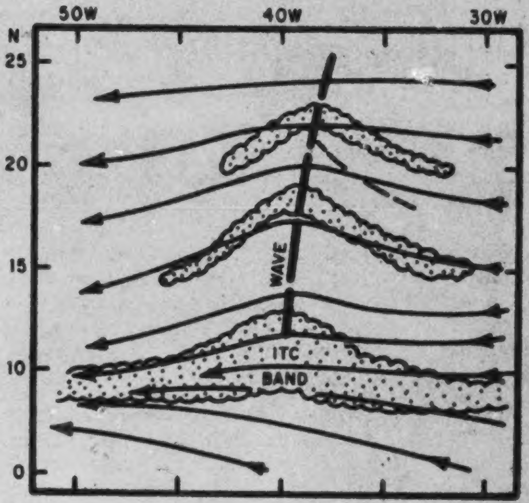
209.373

Figure 14-22.—Basic tropical wave model (A) Vertical; (B) Horizontal.

INTERTROPICAL CONVERGENCE ZONE (ITCZ)

As satellites have provided great amounts of pictorial information to today's meteorologists for research, it has become apparent that some changes in previous theories were needed. One of these so affected is the Intertropical Convergence Zone (ITCZ), or as it is frequently referred to now, zone of Intertropical Confluence (ITC).

The ITCZ is a nearly continuous line of horizontal convergence along the Equatorial


50W
40W
30W
N
25
20
15
10
0
WAVE
ITC
BAND

209.374

Figure 14-23.—Inverted-V tropical wave model.

Trough. Figure 14-24 shows a typical cloud band associated with the ITCZ. It is within this cloud band that disturbances frequently occur.

Generally, disturbances along the ITCZ move from east to west and can move poleward and develop into tropical storms. These disturbances are most frequent in the doldrum portions of the equatorial trough. In that area, low-level cyclonic wind shear is present over large areas. This, together with friction, produces the forced convergence necessary for development of the individual cloud systems which form the ITCZ cloud band.

It has been determined that surges of flow from one hemisphere to the other one of the controlling factors of ITCZ clouds. As air moves across the equator, anticyclogenesis takes place. This results in a reduction or clearing of clouds along one portion of the ITCZ cloud band and an intensification of the cloud band in advance of the burst of cross equatorial field.

Weather Along the ITCZ

The degree and severity of the weather along the ITCZ varies considerably with the

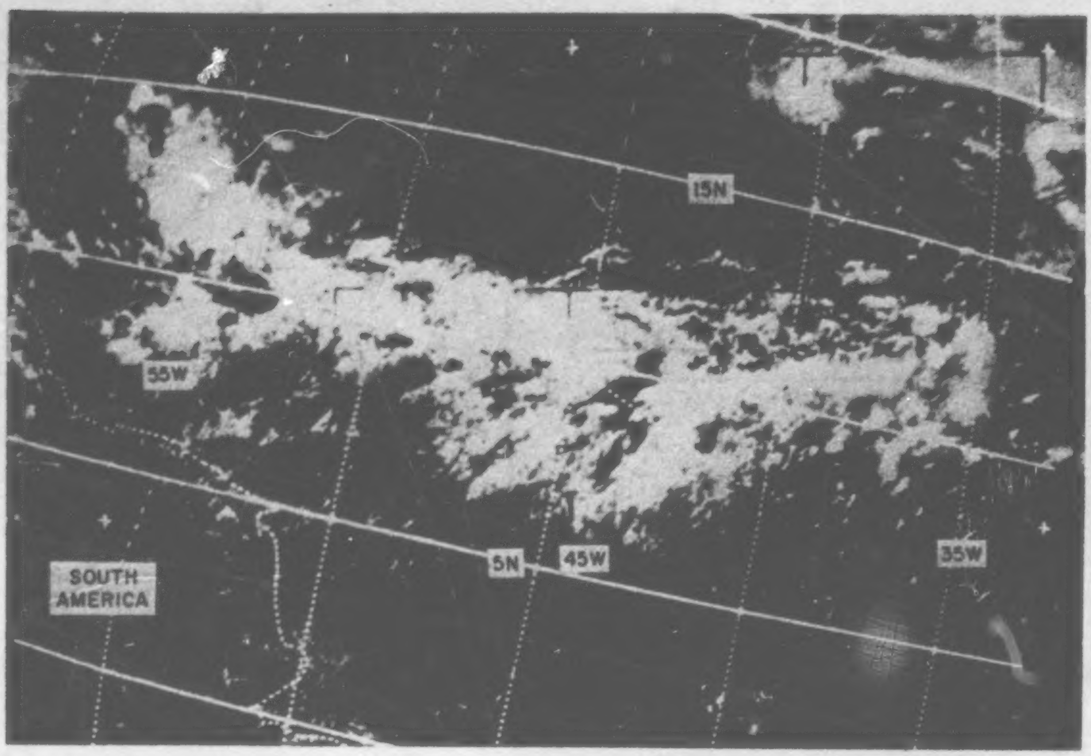


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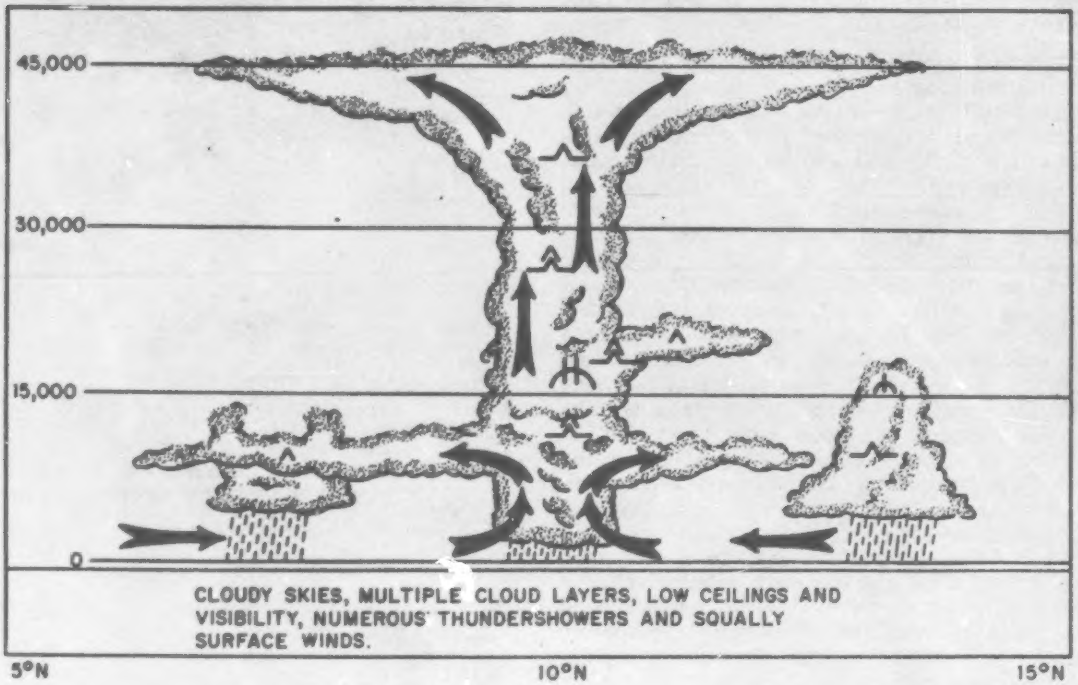
Figure 14-24.—Satellite picture depicting ITCZ in the eastern Atlantic Ocean.

degree of convergence between the two air currents. The zone of disturbed weather may be as little as 20 to 30 miles in width or as much as 300 miles. Under typical conditions, frequent rainstorms, cumulus and cumulonimbus type clouds and local thunderstorms occur. Violent turbulence may be associated within these storms. Cloud bases may lower to below 1,000 feet, or even be indistinguishable, in heavy showers. Their tops frequently exceed 40,000 feet. An extensive layer of altocumulus and altostratus usually occurs due to the spreading out of the upper parts of the clouds. These clouds vary in height and thickness with the currents of the air masses. At higher levels a broad deck of cirrostratus spreads out on both sides of the zone. Visibility is generally good except when reduced by heavy rain shower activity.

Surface wind in the vicinity of the ITCZ is generally squally in the heavy shower areas.

Ice formation in the heavy cloud masses associated with the ITCZ is likely to reach serious proportions when pilots are flying at altitudes above 15,000 feet. (This is roughly the average freezing level in equatorial regions.)

The intensity of the ITCZ varies interdiurnally, from day to day and to a lesser degree annually. Over ocean areas, precipitation reaches its maximum just before dawn with a minimum occurring late in the morning or early afternoon. Over land areas the reverse is true, except on coastal areas when the wind has an onshore component. In this case the diurnal maximum of precipitation takes place in the early morning. (See fig. 14-25.)


45,000
30,000
15,000
0
CLOUDY SKIES, MULTIPLE CLOUD LAYERS, LOW CEILINGS AND VISIBILITY, NUMEROUS THUNDERSHOWERS AND SQUALLY SURFACE WINDS.
5°N
10°N
15°N

209.70

Figure 14-25.—Weather conditions in an active portion of the ITCZ.

Seasonal Variation

The use of mapped digital satellite data has improved the information of the seasonal meridional displacement of the cloud band associated with the ITCZ.

The cloud pictures revealed that the cloud band has somewhat different characteristics in different parts of the world. In the Atlantic, it is centered about 3 degrees north in the winter season and moves to about 8 degrees north by late summer. In the Pacific, the seasonal fluctuations of the cloud band are not readily apparent east of 150 degrees west. Seasonal pressure changes over North America may be responsible for what seasonal shift of the ITCZ cloud band there is in the eastern Pacific. West of 150 degrees the movements are not well defined. The large area of relatively cloud-free skies during the winter season southwest of Central America and Mexico suggests that dry wintertime continental outflow pushes the ITCZ cloud band to the south in this area. There is some evidence of a weak second cloud band associated with the ITCZ along 5 degrees south, during the period January through March. It varies in strength from year to year, occasionally failing to develop at all. The ITCZ band of clouds in the Indian Ocean during the Southern Hemisphere summer is much broader in extent than either of the cloud bands found in the Atlantic or Pacific Oceans.

TROPICAL CYCLONES

The most widespread destructive weather phenomenon is the tropical cyclone, which each year claims lives and causes extensive damage. While a tornado exceeds the severity of a full-fledged tropical cyclone it is generally confined to a smaller area and has a comparatively short path and life duration. The tropical cyclone due to its greater horizontal extent and longer life, exceeds any other phenomena in total damage and loss of life.

Tropical cyclones have been given names in different regions of the world, such as, "Hurricane" in the Atlantic and eastern North Pacific areas; "Typhoons" in the western North Pacific areas; "Willy-Willies" in Australia; and "Baguios" in the Philippines; however, they all have essentially the same characteristics. Although the tropical cyclone normally covers a large area, roughly circular or elliptical in shape (fig. 14-26), it is usually of small size compared with large extratropical cyclones. It differs also in that there are no distinct cold and warm sectors and no well-defined surfaces of discontinuity or fronts at the surface while the cyclone is in the Tropics. The tropical cyclone is found most frequently in summer or autumn of the hemisphere in which it occurs, while the extratropical cyclone is most frequent in cold months. Tropical cyclones have no moving anticyclones as companions while in the Tropics. In many other features, such as the region of calm or relative calm called the "eye," the east to west component of progressive motion in its early history, and the distribution of rainfall, tropical cyclones are distinctive. However, on leaving the Tropics they take on some of the characteristics of extratropical cyclones.

Classification of Tropical Cyclones

The nomenclature of tropical cyclones varies considerably. At times such terms as "tropical cyclone," "tropical storm," "typhoons," and "hurricanes" are used almost interchangeably with little regard for differences in size or intensity. There are generally three recognized categories of nonfrontal cyclones of tropical origin, all of which must show evidence of a closed circulation at the surface. These are distinguished in terms of observed or estimated surface wind speeds associated with the systems as follows:

1. Tropical Depression. Maximum winds less than 34 knots and one or more closed isobars on the surface. Normally these are expected to intensify.
2. Tropical Storm. Closed surface isobars with maximum winds 34 to 63 knots, inclusive.
3. Hurricane/Typhoon. Maximum winds of 64 knots or higher.

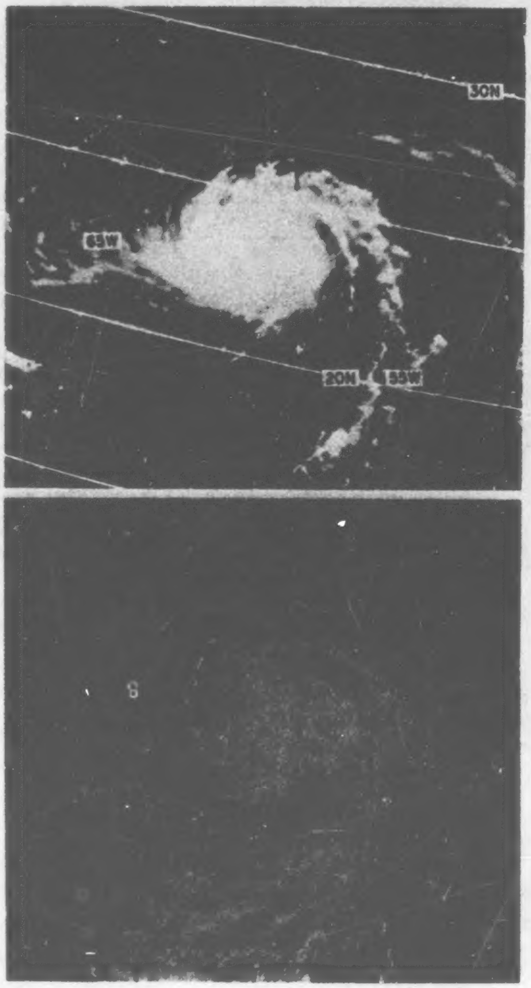


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Figure 14-26. — Satellite pictures of tropical cyclones in the Atlantic Ocean showing their unique circular shape.

Life Cycle of the Tropical Cyclone

The energy that sustains tropical cyclones is derived from the energy that is released through the latent heat of condensation. The energy source is furnished to the tropical storm by the warm water sources over which it develops and moves. The warm moist air is lifted by a combination of convergence and instability of the air until it condenses. Upon condensation the latent heat is liberated. However, if the storm passes over a large landmass, the source of energy is cut off and the storm will eventually dissipate. As the storm moves from southerly latitudes to higher latitudes, the heat source is no longer present and the storm will assume extratropical characteristics.

The average lifespan of this type storm is about 6 days from the time it forms until it either moves over a land surface or recurves to higher latitudes. Some storms last only a few hours, while some last as long as 2 weeks. The evolution of the average storm from birth to dissipation has been divided into four stages:

1. Formative or Incipient Stage. This stage starts with the birth of the circulation and ends at the time that hurricane/typhoon intensity is reached. This stage can be slow, requiring days for a weak cyclonic circulation to begin, or in the case of development on a tropical wave, it can be relatively explosive, producing a well-formed eye in as little as 12 hours. In this stage the minimum pressure reached is about 1,000 millibars. A good indication that a system of this type has formed or is forming is the appearance of westerly winds (usually 10 knots or more) in low tropical latitudes where easterly winds normally prevail.

2. Immature or Intensification Stage. This stage lasts from the time the system reaches hurricane-typhoon intensity until the time it reaches its maximum intensity in winds and its lowest central pressure. The lowest central pressure often drops well below 1,000 millibars, and the wind system becomes organized in a tight ring around the eye with a fair degree of symmetry. The cloud and precipitation fields develop into narrow, inward spiraling bands. Usually the radius of the strongest winds are no more than 60 miles around the center. This development may take place gradually or occur in less than 1 day.

3. Mature Stage. This stage lasts from the time the hurricane/typhoon attains its maximum intensity until it weakens to below this intensity or transforms to an extratropical cyclone. In this stage, the storm may exist for several days at nearly the same level of intensity or decrease slowly. The storm grows in size, with strong winds reaching farther and farther from the center. The weather and winds usually extend farther in the semicircle of the storm to the right of its direction of movement. By the time the storm reaches this stage it is usually well advanced toward the north and west, or it has already recurved into the westerlies. The typhoons of the Pacific usually last longer in the mature stage and grow to larger sizes than hurricanes in the Atlantic.

4. Decaying Stage. This stage may be characterized by rapid decay as in the case of many storms which move inland, or after recurvature, the transformation into a middle latitude cyclone. In the former case the storm steadily loses strength and character. In cases of transformation there is frequently a regeneration in the middle latitudes which results in maintenance or redevelopment of strong winds and other hurricane/typhoon characteristics.

There is no set duration for the time a storm may be in any one stage. It is entirely possible that a storm will skip one stage or go through it in such a short time that it is not distinguishable without the available synoptic data. Satellite picture interpretation has improved the possibility of observing the various stages of tropical cyclones.

Characteristics of Tropical Cyclones

To make the most efficient analysis of available data in the vicinity of tropical cyclones, the forecaster must be familiar with the normal wind, pressure, temperature, clouds, and weather patterns associated with these storms. No two tropical cyclones are exactly alike. On the contrary, there are very great variations between storms. However, certain general features appear with sufficient frequency to predominate in the mean patterns. These features serve as a valuable guide when reconstructing the picture of an individual tropical cyclone from sparse data.

Since the meteorological elements are not distributed uniformly throughout all sections of the storm, it is customary to describe the storms in terms of four quadrants or right and left semicircles, separated by the line along which the center of the storm is moving and normal to this line at the cyclone center.

Actually, in nature there are no clearly defined lines of demarcations between these areas. The general features of hurricanes/typhoons given in the following section apply mainly to the mature stage.

1. Surface Winds. The surface winds blow inward in a counterclockwise direction toward the center with those in the left rear quadrant having the greatest angle of inflow (in the Northern Hemisphere). The diameter of the area affected by the hurricane/typhoon force winds may be in excess of 100 miles in large storms or as small as 25 to 35 miles. Gale winds sometimes cover an area 500 to 800 miles or more. The maximum extent of strong winds is usually in the direction of the major subtropical anticyclone which is most frequently to the right of the line of movement of the storm in the Northern Hemisphere. No accurate measurement of the peak wind speeds of large mature storms has been made with any reliable degree of accuracy. Speeds of 140 knots have been recorded and it seems reasonable to assume that speeds of 200 knots may be attained at altitudes several hundred feet above the surface.

2. Surface Pressure. Since the central surface pressure of the mature storm is well below average, sea level isobars furnish an excellent tool for analysis of these storms. Isobars may be nearly symmetrical or they may assume an elliptical shape. The pressure gradient to the right of the storm's motion is strongest due to the forward motion of the storm against the existing pressure gradient. Various other deformations may occur, such as the extension of a trough southward from the storm. Barometric tendencies are not a particularly good indication of the movement of the storm outside of its sphere of influence. Usually the pressure falls with extreme rapidity in the 3 hours before the arrival of the storm and rises at an equal rate after passage. Central pressures of 950 to 960 millibars are not uncommon.

3. Surface Temperature. In contrast to extratropical cyclones the tropical cyclone may show no, or very little, surface temperature reductions toward the center of the storm, indicating that the horizontal adiabatic cooling due to the pressure reduction is largely offset by the addition of the heat through the release of heat to the atmosphere through the condensation processes. Upper air temperatures, it has been found, are actually higher by 5° C or more.

4. Clouds. The cloud patterns of tropical cyclones are also at variance with those of the extratropical cyclones. In mature cyclones almost all the cloud forms are found to be present, to be sure, but by and large the most significant clouds of these storms are the heavy cumulus and cumulonimbus which spiral inward toward the edge of the eye of the storm, becoming generally more massive and closely spaced as they approach the eye. These spiral bands, especially the leading ones, are also referred to as BARS. Cirrus and cirrostratus occupy by far the largest portion of the sky over the tropical cyclone area. In fact, cirrus, becoming more dense, changing to cirrostratus and lowering somewhat, are more often than not the first indicators of the approach of a distant storm or the development of one in the near vicinity. The original appearance of the sky is very similar to that of an approaching warm front.

5. The Eye. The eye of the storm (fig. 14-27) is one of the oldest phenomena known in meteorology. Precipitation ceases abruptly at the boundary of a well-developed eye; the sky partly clears; and the wind subsides to less than 15 knots, and at times there is a dead calm. The sun or the stars become visible. In mature storms, the diameter of the eye averages about 15 miles, but it may attain 40 miles in large typhoons. The eye is not always circular, sometimes it becomes elongated and even diffuse with a double structure appearance. Radar observations indicate that the eye is constantly undergoing transformation and does not stay in a steady state.

6. Precipitation. Very heavy rainfall is generally associated with mature cyclones. However, the methods of measurement are subject to such large errors during high winds that representative figures on the normal amount and distribution of precipitation cannot be said to exist. Precipitation is generally concentrated in the inner core where the slope of the barograph trace is the highest. Amounts of 20 inches are not uncommon. Over the open sea, rainfall is considered of operational interest primarily from the standpoint of its effect on ceiling and visibility. Over land,

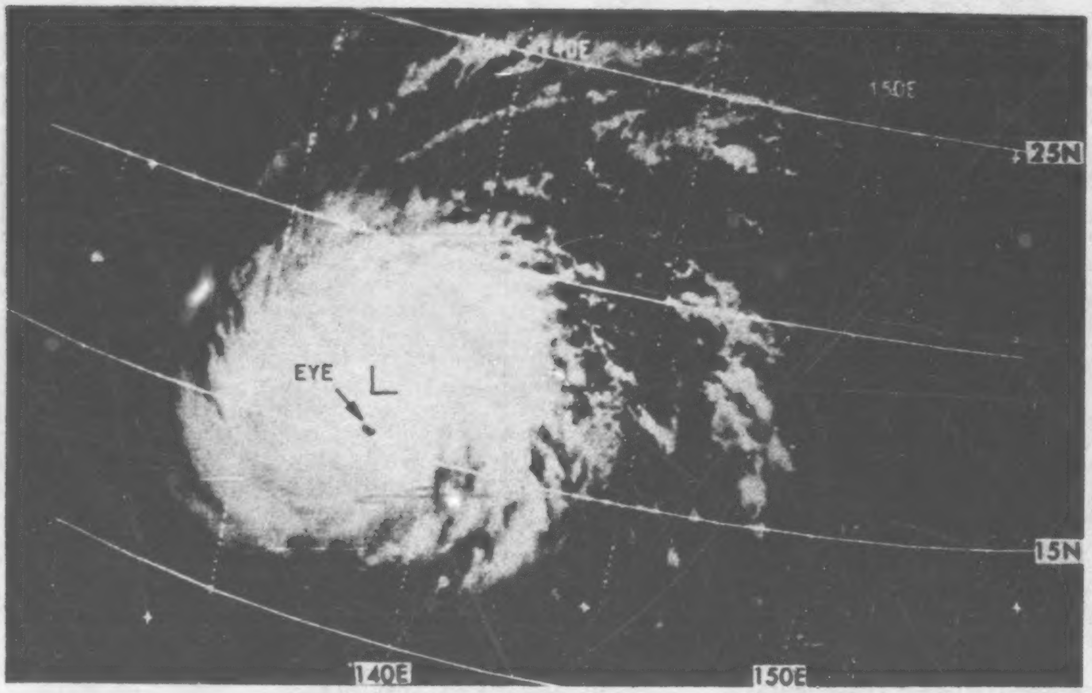

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Figure 14-27.—Satellite picture of typhoon Gilda in the Pacific Ocean showing a distinct "eye".

orographic effects produce concentrations of rainfall, which often results in costly floods. Hurricane force winds forcing moisture-laden tropical air up a steep mountain slope often result in phenomenal rainfall. A fall of 88 inches was recorded during one storm in the Philippines. At the other extreme, as little as a trace has been recorded at a station in Florida, which had winds up to 120 knots during the passage of a hurricane.

7. State of the Sea. One of the first signs of the tropical storm is the swell, which comes in a series of waves with the time interval between crests considerably longer than in waves usually observed in the Tropics. Winds of the storm create waves on the sea which move outward from its center more rapidly than the storm progresses and thus outrun the storm and herald its approach. As the wave moves onward, its height from crest to trough diminishes, its length is reduced, and it becomes a low undulating wave, known as a swell. The size and speed of waves created by the winds depend upon the velocity of the winds and the length of water surface over which the winds blow.

In a tropical cyclone the waves and swell move outward from the storm center at a rate which nearly always exceeds the speed of progressive movement of the storm. The swell waves continue to move in a straight line through the storm area, whereas the winds turn to the left in the Northern Hemisphere and to the right in the Southern Hemisphere.

The direction of swell waves in the open sea gives some indication of the location of the storm center. When considered in connection with the direction of the wind, the movement of the swell waves is significant.

The period of the swell waves, that is, the time in seconds between the passage of successive swell wave crests, is helpful in determining the intensity of the storm. In the Caribbean Sea and the Gulf of Mexico long period swell waves do not commonly occur except in connection with a tropical storm.

Table 14-3.—Tropical cyclone data

		Atlantic Ocean	Pacific Ocean	Indian Ocean
NORTHERN HEMISPHERE	Areas of formation.	1. Cape Verde Islands and westward. Western Caribbean. 2. Gulf of Mexico.	1. Marshall Islands, Caroline Islands, Philippines, and South China Sea. 2. Gulf of Tehuantepec to Revillagigedo Island.	1. Bay of Bengal. 2. Laccadive Islands to Maldive Islands.
	Main tracks.	1. Through West Indies and northward to U.S. or ocean area OR into Central America. 2. West or north.	1. Through or near Philippines and northward toward China, Japan, etc. 2. Northwestward to Lower California or halfway to Hawaiian Islands.	1. Clockwise path into India or Burma. 2. Clockwise path into India or Gulf of Oman.
	Highest frequency months.	Aug., Sept., Oct.	1. July, Aug., Sept., Oct. 2. Sept., Oct.	1. June to Nov., inclusive 2. June, Oct., Nov.
SOUTHERN HEMISPHERE	Areas of formation.	None	Coral Sea and west of Tuamotu Islands.	1. Cocos Islands and westward. 2. Timor Sea.
	Main tracks.	None	Counterclockwise along northeast Australian coast or toward New Zealand. Westward to Coral Sea.	1. Westward, then counterclockwise southward near Madagascar. 2. Counterclockwise along northwest Australian coast.
	Highest frequency months.	None	Jan., Feb., Mar..	1. July, Aug., Sept. 2. July, Aug., Sept.

The appearance of heavy swell waves with a period of 9 to 15 seconds during the hurricane season in those waters is an indication of the existence of a tropical storm in the direction from which the swell waves come; the longer swell wave period, 12 to 15 seconds, are almost certain signs of the hurricane.

One of the most severe effects of hurricane damage occurs along coastal areas by large ocean waves. The most severe waves can be expected where land partially surrounds bodies of water such as the Bay of Bengal and the Gulf of Mexico. Strong sustained winds in the right-hand semicircle cause a piling up of water along coastal areas as much as 10 feet above normal. Sometimes these tides are referred to as storm tides. An even greater threat is the so-called hurricane wave. The term "hurricane wave" has been applied to the marked rise in the level of the sea near the center of intense tropical cyclones. This rise sometimes amounts to 20 feet or more and affects small isolated islands as readily as continental shores. In partially enclosed seas they may be superimposed on the hurricane and gravitational tides. The hurricane wave may occur as a series of waves, but is usually one huge wave. These waves have produced many of the major hurricane disasters of history. There is usually little warning of their approach. However, they should be anticipated near, and to the right of, the center of intense tropical cyclones.

8. Vertical Characteristics. The vertical structure of a tropical cyclone also differs considerably from the extratropical cyclone. The first difference is that the tropical cyclone is always a warm core low. The storm may build from the top down as well as from the surface upward, and it is for this reason that only the mature model should be considered for comparison. Subsidence occurs in the eye of the storm below about 30,000 feet extending to about 3,000 feet above the surface, accounting for the lack of or sparsity of low and middle clouds.

There is present in a mature storm, considerable horizontal and vertical mixing, extending from near the surface to between 10,000 and 20,000 feet. There is a net horizontal inflow of air at all levels to about 3,000 feet or higher, above which there is a net horizontal outflow of air. This net outflow of air is usually very pronounced in the vicinity of the 200-mb level, and it is for this reason that the 200-mb level is one of the primary analysis tools in the Tropics. The outflow at the 200-mb level is manifested by an anticyclonic flow, unless the storm is unusually severe and penetrates even that level, in which case the flow is cyclonic.

Seasons and Regions of Occurrence

Tropical cyclones may occur during any month of the year with a maximum occurrence from May to November. Frequency, however, varies from ocean to ocean.

There are nine principal regions of tropical cyclone formation. Six regions are in the Northern Hemisphere, three, in the Southern Hemisphere. The South Atlantic Ocean is entirely free from tropical cyclones. The southwestern North Pacific, on the other hand, has by far the greatest number of tropical cyclones developing in it. A detailed breakdown of formation areas, with main tracks and months of most frequent occurrence, is found in table 14-3.

Not all tropical cyclones reach hurricane intensity. Tropical cyclones that reach hurricane intensity are more prevalent in the respective late summer and early fall in both the Northern and Southern Hemispheres. This does not preclude the formation or the intensification of tropical cyclones of any intensity during the other seasons. Tropical cyclones are also much less frequent than the extratropical ones.

CHAPTER 15

METEOROLOGICAL ELEMENTS

When the term "meteorological elements" is used, it is in reference to those elements which are responsible for the formation of weather within the atmosphere.

Most weather, as it is known and as it has a bearing on naval operations, occurs in that portion of the atmosphere referred to as the troposphere. The meteorological elements that comprise this weather are temperature, atmospheric pressure, humidity, hydrometeors, lithometeors, photometeors, electrometeors, and wind. Temperature, atmospheric pressure, wind and humidity were discussed in previous chapters of this training manual.

This chapter will be confined to discussing hydrometeors, lithometeors, photometeors, and electrometeors occurring below the tropopause (within the troposphere). Above the tropopause, little or no weather occurs, except for the aurora, because water vapor is present only in very small quantities. The presence of water vapor in the air is the most important factor controlling the type and intensity of weather.

HYDROMETEORS

Hydrometeors consist of liquid or solid water particles which are either falling through or suspended in the atmosphere, blown from the surface by wind, or deposited on objects. Hydrometeors comprise all forms of precipitation, such as rain, drizzle, snow, and hail, and such elements as clouds, fogs, blowing snow, and dew.

PRECIPITATION

Precipitation includes all forms of moisture that fall to the earth's surface, such as rain, snow, hail, drizzle, etc. Dew and frost are not forms of precipitation, although they are hydrometeors. Precipitation is classified according to both its form (liquid, freezing, and solid) and size (and rate of fall). The size of precipitation drops determines their rate of fall to a large extent. Also, the size determines some of the different types of precipitation.

Rain

Precipitation which reaches the earth's surface as water droplets with a diameter of 0.02 inch (0.5 mm) or more is classified as rain. If the droplets freeze on contact with the ground or other objects, the precipitation is classified as freezing rain. Rain emanating from convective clouds is referred to as rain showers. Showers usually start and stop rather suddenly; they are quite intermittent in character; and the drops of which they are composed are usually larger and the impact (therefore the intensity) of the drops is greater than with other types of rain.

Drizzle

Drizzle consists of very small and uniformly dispersed droplets that may appear to float while following air currents. Sometimes drizzle is referred to as mist. Unlike fog droplets, drizzle falls to the ground. However, the rate of fall is very slow. The slow rate of fall and the small size of the droplets distinguish drizzle from rain. When the droplets freeze on contact with the ground or other objects, they are called freezing drizzle. Drizzle usually restricts visibility.

Snow

Snow consists of white or translucent ice crystals. In their pure form the ice crystals are highly complex, hexagonally branched forms.

However, most snow falls as parts of crystals, as individual crystals, or more commonly as clusters and combinations of these. Snow occurs in meteorological conditions similar to those in which rain occurs, except that with snow the initial temperatures must be at or below freezing. Snow falling from convective clouds is termed snow showers.

Snow Pellets

Snow pellets are white, opaque, round (or occasionally conical) kernels of snowlike consistency, 0.08 to 0.2 inch in diameter. They are crisp and easily compressible. They may rebound or burst when striking hard surfaces. They occur almost exclusively in showers.

Snow Grains

Snow grains consist of precipitation of very small, white, opaque grains of ice similar in structure to snow crystals. When the grains hit hard ground, they do not bounce or shatter. They usually fall in small quantities, mostly from stratus, and never as showers.

Ice Pellets

Ice pellets are transparent or translucent pellets of ice which are round or irregular, rarely conical, and which have a diameter of 0.2 inch or less. They usually rebound when striking hard ground and make a sound on impact. There are two main types of ice pellets. One is composed of hard grains of ice consisting of frozen raindrops or largely melted and refrozen snowflakes (formerly "sleet"); this type falls as continuous precipitation. The other type is composed of pellets of snow encased in a thin layer of ice which has formed from the freezing of either droplets intercepted by the pellets or of water resulting from the partial melting of the pellets; this type falls as showery precipitation.

Hail

Ice balls or stones, ranging in diameter from that of a medium-size raindrop to an inch or more, are referred to as hail. They may fall detached or frozen together into irregular, lumpy masses. They are composed either of clear ice or of alternating clear and opaque snowflake layers. Hail forms in cumulonimbus clouds and is associated with thundershower activity. Surface temperatures are usually above freezing when hail occurs. Determination of size is based on the diameter, in inches, of normally shaped hailstones.

Ice Prisms (Ice Crystals)

A fall of unbranched ice crystals in the form of needles, columns, or plates. These are often so tiny that they seem to be suspended in the air. They may fall from a cloud or from clear air. In an Aviation Observation they are called Ice Crystals. They are visible mainly when they glitter in the sunlight or other bright light; they may even produce a luminous pillar or other optical phenomena. This hydrometeor which is frequent in polar regions, occurs only at very low temperatures in stable air masses.

Rime

Rime is a deposit of ice composed of grains more or less separated by air. Sometimes it is adorned with crystalline branches. It forms when supercooled water droplets strike an object at a temperature below freezing.

Glaze (Clear Ice)

A coating of ice, generally clear and smooth, but with some air pockets. It is formed on exposed objects at temperatures below or slightly above 32°F by freezing of supercooled drizzle or rain drops. Glaze is denser, harder, and more transparent than rime.

Drifting and Blowing Snow

The result of snow particles being raised from the ground by a strong turbulent wind. Drifting snow consists of particles being lifted to small heights above the ground, and visibility is not less than 7 miles at eye level although obstructions below this level may be veiled or hidden by the particles moving nearly horizontal to the ground. Blowing snow, however, consists of particles raised and stirred violently to moderate or great heights. Visibility is poor, less than 6 miles, and the sky may become obscured when the particles are raised to the greater heights.

Spray and Blowing Spray

Spray consists of water droplets torn by the wind from a substantial body of water, generally from the crests of waves, and carried up a short distance into the air. Blowing spray occurs when the spray is raised in such quantities as to reduce the visibility at eye level (6 feet on shore, 33 feet at sea) to 6 miles or less.

Precipitation Theory

Precipitation is an outgrowth of condensation. The condensation theory is discussed in this chapter under "Cloud Formation." The main concern at the present time is with the growth of condensed water droplets and their subsequent descent to the earth's surface.

Several theories have been formulated in regard to the growth of raindrops, and all of them have some validity. The theories which are most widely accepted today are treated here in combined form.

Raindrops grow in size primarily because water exists in all three phases in the atmosphere (see chapter 3), and the air is supersaturated at times (especially with respect to ice) due to adiabatic expansion and radiational cooling. This means that ice crystals coexist with liquid water droplets in the same cloud. The difference in the vapor pressures between the water droplets and the ice crystals causes water droplets to evaporate and then to sublimate directly onto the ice crystals. Condensation alone does not cause droplets of water to grow in size. The turbulence in clouds permits this droplet growth process and aids it. After the droplets become larger, they start to descend and are tossed up again in turbulent updrafts within the cloud. The repetition of ascension and descension causes the ice crystals to grow larger (by water vapor sublimating onto the ice crystals) until finally they are heavy enough to fall out of the cloud as some form of precipitation. It is believed that most precipitation in the midlatitudes starts as ice crystals and that most liquid precipitation results from melting during descent through a stratum of warmer air. It is generally believed that most rain in the Tropics forms without going through the ice phase.

In addition to the above process of droplet growth, simple ACCRETION is important. The droplets colliding with other smaller ones simply hold the smaller ones, and the droplets thereby accumulate more layers. During the growing process, the droplets which form the outer layers are frozen onto the larger droplets. This process of accretion is thought to be especially effective in the growth of hail. There are, to be sure, other factors which explain in part the growth of precipitation, but the aforementioned processes are the primary ones.

CLOUDS

A cloud is a visible mass of minute water droplets, or ice particles, suspended in the atmosphere. It differs from fog in that it does not reach to the surface of the earth. Clouds are a direct expression of the physical processes which are taking place in the atmosphere. An accurate description of both type and amount plays an important part in the analysis of the weather and in forecasting the changes which are taking place in the weather.

Cloud Formation

To be able to thoroughly understand clouds, the Aerographer's Mate must know the physical processes which form clouds.

Three conditions must be met before clouds can form as a result of condensation—presence of sufficient moisture, a cooling process, and hygroscopic or sublimation nuclei in the atmosphere. Moisture is supplied to the atmosphere by evaporation and is distributed horizontally and vertically by the winds and vertical currents. The first task is to consider the hygroscopic and sublimation nuclei.

Hygroscopic nuclei are particles of any nature on which condensation of atmospheric moisture occurs as a liquid. It can be said that hygroscopic nuclei have an affinity for water or that they readily absorb and retain water. The most effective hygroscopic nuclei are the products of combustion (sulfuric and nitric acids) and salt sprays. Some dust particles are also hygroscopic, but not effectively so. As has been stated, the presence of hygroscopic nuclei is a must. Water vapor does not readily condense without their presence. Air has been supersaturated in laboratories to over 400 percent before condensation began when there were no hygroscopic nuclei present. On the other hand, condensation has been induced with relative humidities of only

70 percent when there was an abundance of hygroscopic nuclei.

The condensation which results when all three mentioned conditions are fulfilled is in the form of clouds, fogs, or haze. Fogs are merely clouds on the surface of the earth. Fogs receive treatment in a separate section of this chapter.

In our industrial cities in which byproducts of combustion are profuse, the distinction between smoke, fog, and haze is not easily discernible. A combination of smoke and fog gives rise to the existence of the so-called 'smogs' which are characteristic of these industrial areas.

Little is known about the properties of sublimation nuclei, although it is believed that they are essential for sublimation to occur at all. It is assumed that sublimation nuclei are very small and very rare, possibly of a quartz or meteoric dust origin. All cirriform clouds are composed of ice crystals and are believed to be formed as a result of direct sublimation. Sublimation is the process whereby water vapor changes into ice without passing through the liquid stage.

In the atmosphere, water clouds, water and ice crystal clouds, and pure ice crystal clouds may exist at the same time.

Next under consideration is the cooling process which may induce condensation. There are several processes by which the air is cooled—convective cooling by expansion, mechanical cooling by expansion, and radiational cooling. Any of the three methods may be working in conjunction with another method, thus making it even more effective. The methods are as follows:

1. Convective cooling. The ascent of a limited mass of air through the atmosphere due to surface heating is called thermal convection. If a sample of air is heated, it rises (being less dense than the surrounding air) and decreases in temperature at the dry adiabatic lapse rate until the temperature and dewpoint are the same. This is the saturation point at which condensation begins. As the parcel continues to rise, it cools at a lesser rate, the moist/saturation adiabatic lapse rate. (An adiabatic process is one in which no heat is added to or taken away from the mass of air by exchange with its environment during the process.) The parcel of air continues to rise until the surrounding air has a temperature equal to, or higher than, the parcel of air. Then convection ceases. Cumuliform clouds are formed by this means with their bases at the altitude of saturation and their tops at the point where the temperature of the surrounding air is the same as, or greater than, the temperature of the parcel of air.

2. Mechanical cooling. In this section, orographic and frontal processes for cloud formation are discussed as follows:

a. Orographic. If air is comparatively moist and is lifted over mountains or hills, clouds may often be formed. The type of cloud depends upon the lapse rate (the rate of decrease in temperature with increase in height unless otherwise specified) of the air. If the lapse rate is weak (that is, a small rate of cooling with an increase in altitude), the clouds formed are of the stratiform type. If the lapse rate of the air is steep (that is, a large rate of cooling with increasing altitude), the clouds formed are of the cumuliform type.

b. In the previous chapter, you learned that, at frontal surfaces, the warmer, less dense air is forced to rise along the surfaces of the colder air masses. The lifted air undergoes the same type of adiabatic cooling as air lifted orographically. Likewise, the type of clouds which results, depends on the lapse rate and moisture of the warm air and the amount of lifting. The latter is determined by the slope of the front; if the slope is very shallow, the air may not be lifted to its saturation point and clouds will not form. When the slope is steep, as with a fast-moving cold front, and the warm air is unstable, clouds are of the cumuliform type with great vertical extent.

3. Radiational cooling. At night the earth radiates long-wave radiation, thereby cooling rapidly. The air in contact with the surface is not heated by the outgoing radiation but, instead, is cooled by contact with the cold surface. This contact cooling lowers the temperature of the air near the surface, causing a surface inversion. If the temperature of the air is cooled to its dewpoint, fog and/or low clouds form. Clouds formed in this manner dissipate during the day due to surface heating.

Cloud Classification

The international classification which has been adopted by most countries is a great help to pilots and meteorological personnel alike. The importance of an international classification of clouds cannot be overestimated, since it tends to make cloud observations standard throughout the world. As for the pilot, if he can properly interpret the meaning of clouds, he is usually able to avoid the types which are dangerous to aircraft.

Clouds have been divided into etages, genera, species, and varieties. This classification is based primarily on the process which produced the clouds. Although clouds are continually in a process of development and dissipation, they nevertheless have many distinctive features which make this classification possible.

ETAGES.—Observations have shown that clouds are generally encountered over a range of altitudes varying from sea level to about 60,000 feet in the Tropics, to about 45,000 feet in middle latitudes, and to about 25,000 feet in polar regions. By convention, the part of the atmosphere in which clouds are usually present has been vertically divided into three etages—high, middle, and low. Each etage is defined by the range of levels at which clouds of certain genera occur most frequently.

Cirrus, cirrocumulus, and cirrostratus are always found in the high etage. Altocumulus and altostratus are found in the middle etage, but altostratus may often extend into the high etage. Nimbostratus is invariably found in the middle etage, but may extend into the high, and especially the low etage. Cumulus, cumulonimbus, stratus, and stratocumulus are always associated with the low etage, but the tops of cumulus or cumulonimbus may extend into either or both of the two other etages.

The HIGH ETAGE extends from about 10,000 to 25,000 feet in polar regions, 16,500 to 45,000 feet in temperate regions, and 20,000 to 60,000 feet in tropical regions.

The MIDDLE ETAGE extends from about 6,500 to 13,000 feet in polar regions, 6,500 to 23,000 feet in temperate regions, and 6,500 to 25,000 feet in tropical regions.

The LOW ETAGE extends from near the earth's surface to 6,500 feet in all regions of the earth.

GENERA.—The genera of clouds are as follows:

1. Cirrus (CI): Thin featherlike clouds.
2. Cirrocumulus (CC): Thin cotton or flakelike clouds.
3. Cirrostratus (CS): Very thin high sheet cloud.
4. Altocumulus (AC): Sheep-back-like clouds.
5. Altostratus (AS): Medium high uniform sheet cloud.
6. Nimbostratus (NS): Dark, threatening, amorphous, and rainy layer.
7. Stratocumulus (SC): Globular masses or rolls.
8. Stratus (ST): Low uniform sheet cloud.
9. Cumulus (CU): Dense dome-shaped puffy looking clouds.
10. Cumulonimbus (CB): Cauliflower towering clouds with cirrus veils on top.

NOTE: Some publications show the abbreviations with the second letter in lower case; i.e. Ci; the abbreviations used here are in accordance with FMH-1.

SPECIES.—The following are the definitions of the species of clouds whose names are commonly used; others may be found in the International Cloud Atlas.

Castellanus. Clouds which present, in at least some portion of their upper part, cumuliform protuberances in the form of turrets. The turrets, which are generally taller than they are wide, are connected to a common base. The term applies mainly to cirrocumulus, altocumulus, and stratocumulus, but especially altocumulus.

Stratiformis. Clouds which are spread out in an extensive horizontal sheet or layer. The term applies to altocumulus, stratocumulus, and occasionally to cirrocumulus.

Lenticularis. Clouds having the shape of lenses or almonds, often very elongated and having well-defined outlines. The term applies mainly to cirrocumulus, altocumulus, and stratocumulus.

Fractus. Clouds in the form of irregular shreds, which have a clearly ragged appearance. The term applies only to stratus and cumulus.

Humilis. Cumulus clouds of only a slight vertical extent; they generally appear flattened.

Congestus. Cumulus clouds which are markedly sprouting and are often of great vertical extent. Their bulging upper part frequently resembles cauliflower.

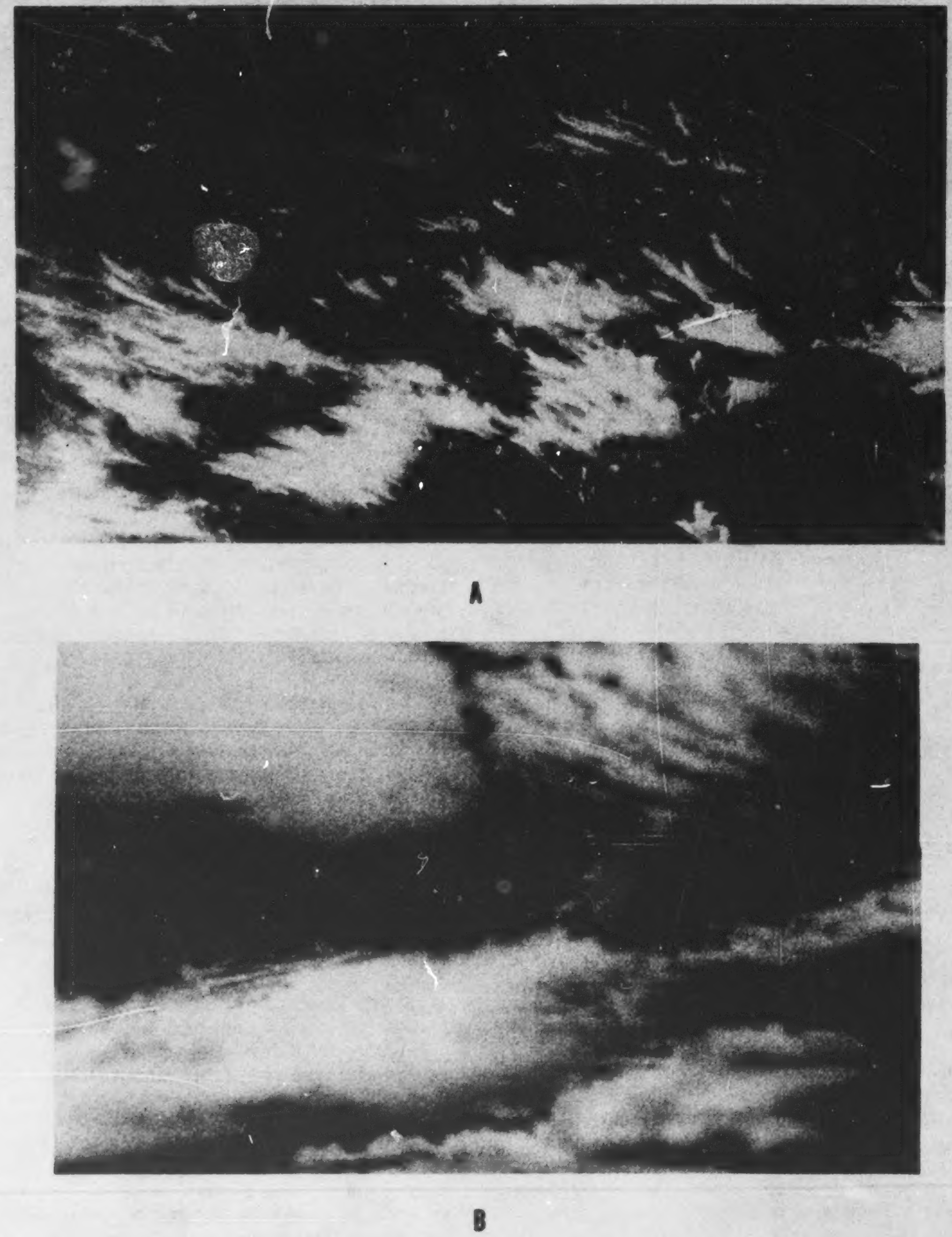

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Figure 15-1.—Cloud examples (A) Cirrus (B) Cirrocumulus.

VARIETIES AND SUPPLEMENTARY FEATURES.—Varieties of clouds are established mainly on the basis of the cloud's transparency or its arrangement in the sky. The varieties are nine in number; but since observations of clouds do not ordinarily involve the recording of the specific variety, they are not covered here. A detailed description of the several varieties can be found in the International Cloud Atlas. Supplementary features and accessory clouds, like the varieties, aid in the clear identification of clouds. The most common supplementary features are mamma, virga, and tuba. They are defined and associated with the parent clouds in the next section on Cloud Types.

Cloud Types

HIGH CLOUDS.—High clouds are described as follows:

1. Cirrus (CI). Cirrus (fig. 15-1(A)) are detached clouds of delicate and fibrous appearance, generally white (cirrus are the whitest clouds in the sky) in color, without shading. They appear in the most varied forms, such as isolated tufts, lines drawn across the sky, branching feather-like plumes, and curved lines ending tufts.

Since cirrus are composed of ice crystals, their transparent character depends upon the degree of separation of the crystals.

Before sunrise and after sunset, cirrus may still be colored bright yellow or red. Being high altitude clouds, they light up before lower clouds and fade out much later.

Cirrus often indicate the direction in which a storm may lie.

2. Cirrocumulus (CC). Cirrocumulus (fig. 15-1(B)), commonly called mackerel sky, look like rippled sand or like cirrus containing globular masses of cotton usually without shadows. Cirrocumulus are an indication that a storm is probably approaching. The individual globules of cirrocumulus are rarely larger than 1 degree as measured by an observer on the surface of the earth at or near sea level.

3. Cirrostratus (CS). Cirrostratus (fig. 15-2(A)) are a thin, whitish veil, which does not blur the outlines of the sun or the moon, but gives rise to halos. A milky veil of fog, thin stratus, and altostratus are distinguished from a veil of cirrostratus of similar appearance by the halo phenomenon, which the sun or moon nearly always produces in a layer of cirrostratus.

The appearance of cirrostratus is a good indication of rain. In the Tropics, however, cirrostratus quite often may be observed with no rain following.

MIDDLE CLOUDS.—Middle clouds are described as follows:

1. Altocumulus (AC). Altocumulus (fig. 15-2(B)) are a layer (or patches) of clouds composed of flattened globular masses, the smallest elements of the regularly arranged layer being fairly small and thin, with or without shading. The balls or patches usually are arranged in groups, in lines, or in waves. This cloud form differs from cirrocumulus by generally having larger masses, by casting shadows, and by having no connection with cirrus forms. A corona or irisation is frequently observed on altocumulus.

2. Altostratus (AS). Altostratus (fig. 15-3(A)) look like thick cirrostratus, but without halo phenomena; altostratus are a fibrous veil or sheet, gray or bluish in color. Sometimes the sun or moon is completely obscured.

Light rain or heavy snow may fall from a cloud layer that is definitely altostratus.

Altostratus can sometimes be observed at two different levels in the sky and sometimes in conjunction with altocumulus, which may also exist at two different layers in the sky.

3. Nimbostratus (NS). Nimbostratus (fig. 15-4) appear as a low, amorphous, and rainly layer of clouds. Of a dark gray color, they are usually nearly uniform and feebly illuminated, seemingly from within.

When precipitation occurs, it is in the form of continuous rain or snow. However, nimbostratus may occur without rain or snow reaching the ground. In cases in which the precipitation does not reach the ground, the base of the cloud is usually diffuse and looks wet.

In most cases, nimbostratus evolve from altostratus layers which grow thicker and whose

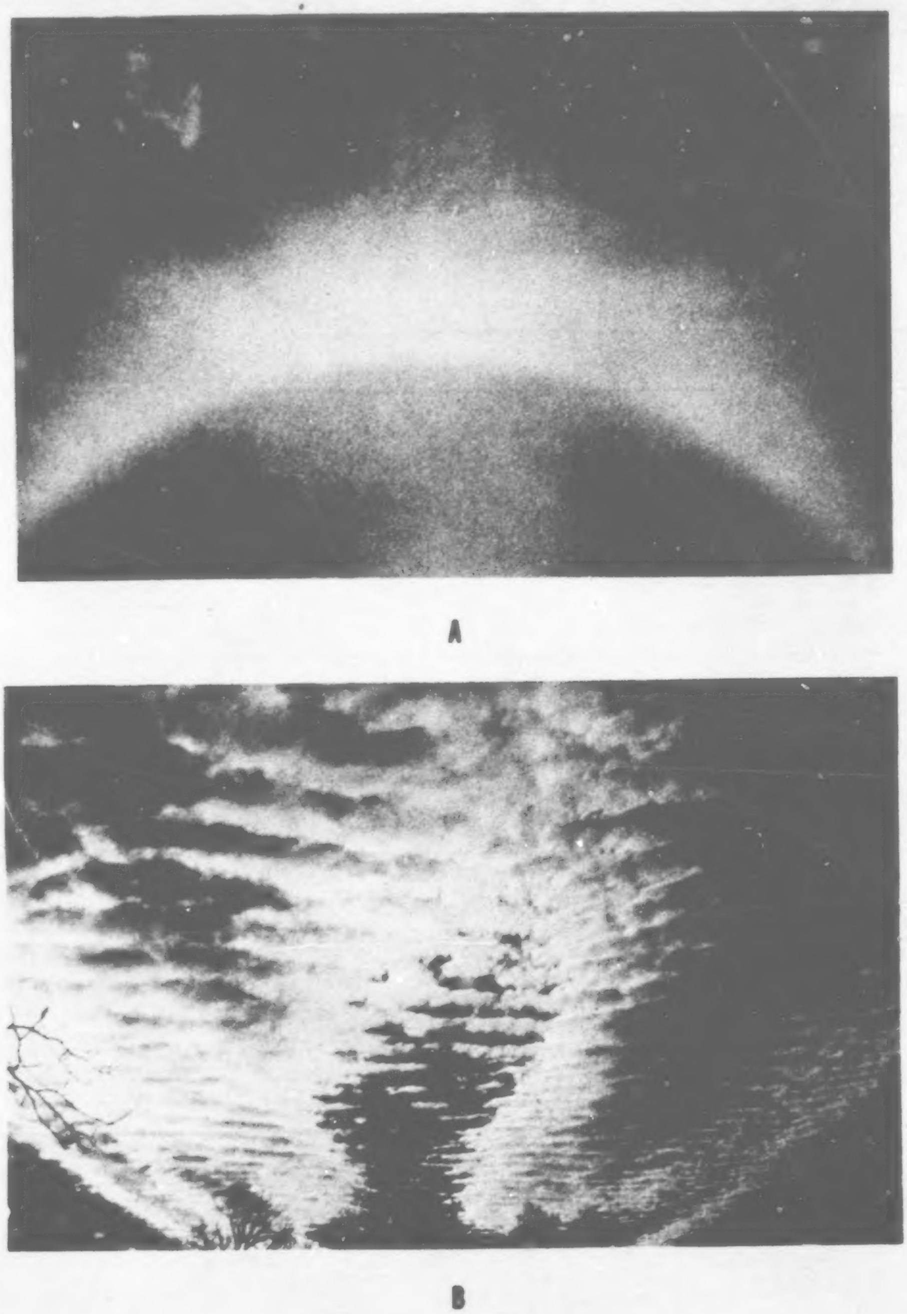

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Figure 15-2.—Cloud examples (A) Cirrostratus (B) Altocumulus.

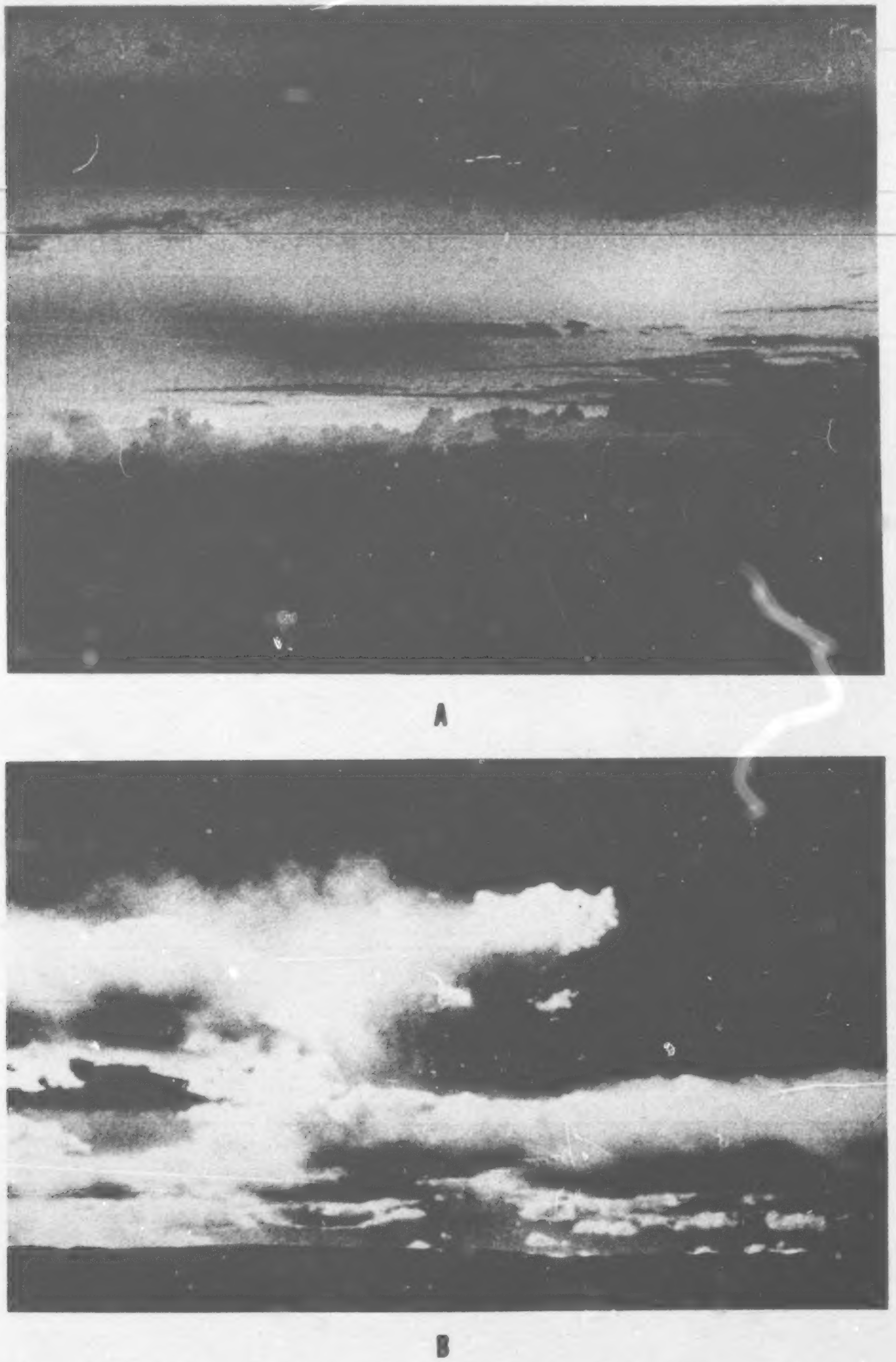

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Figure 15-3. — Cloud examples (A) Altostratus (B) Stratocumulus.

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Figure 15-4.—Nimbostratus.

bases become lower until they become a layer of nimbostratus.

LOW CLOUDS.—Low clouds are described as follows:

1. Stratocumulus (SC). Stratocumulus (fig. 15-3(B)) are a layer (or patches) of clouds composed of globular masses or rolls. The smallest of the regularly arranged elements are fairly large. They are soft and gray, with darker spots.

2. Stratus (ST). Stratus (fig. 15-5) are a low, uniform layer of clouds, resembling fog, but not resting on the ground. When a layer of stratus is broken up into irregular shreds, it is designated as stratus fracto.

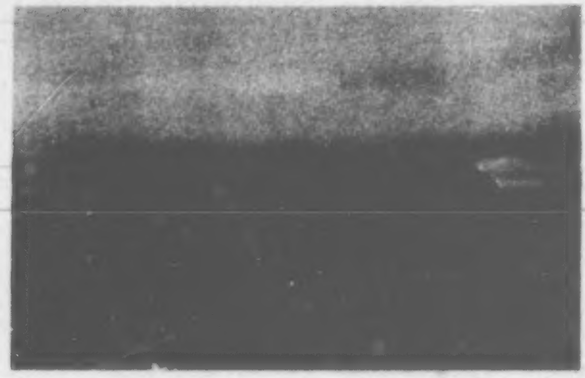

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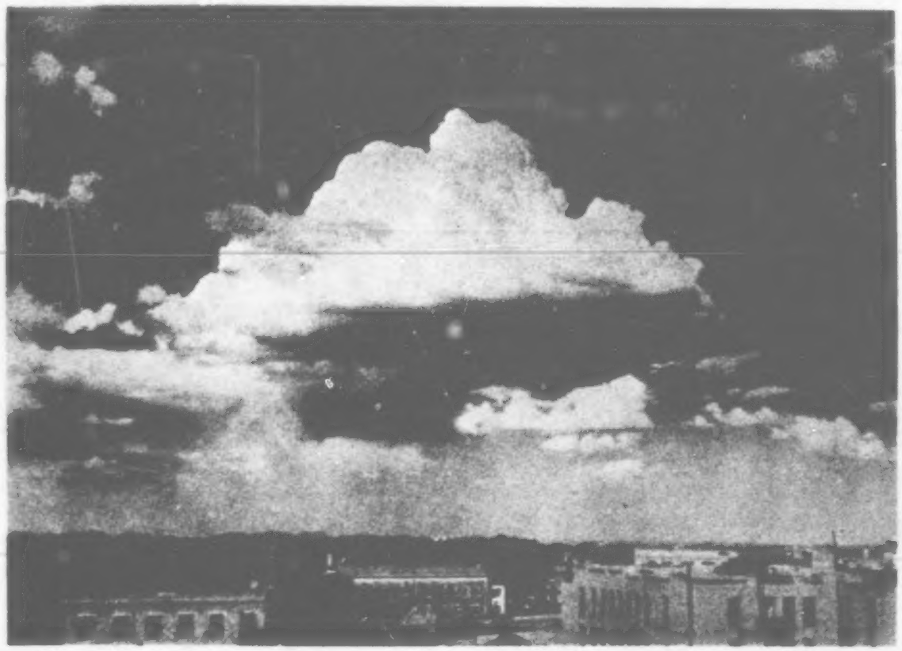
Figure 15-5.—Stratus.

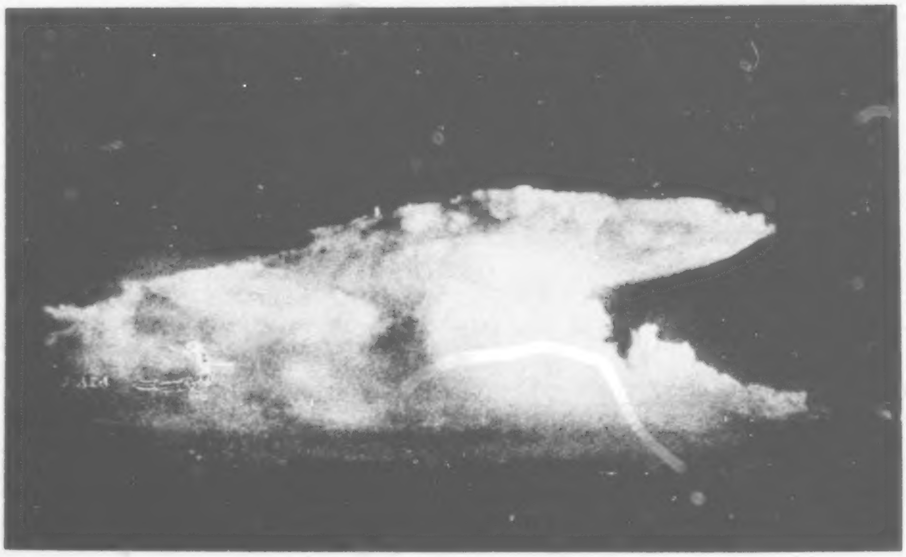
A veil of stratus gives the sky a characteristically hazy appearance. Usually, drizzle is the only precipitation associated with stratus. When there is no precipitation, the stratus cloud form appears drier than other similar forms, and it shows some contrasts and some lighter transparent parts.

3. Cumulus (CU). Cumulus (fig. 15-6(A)) are dense clouds with vertical development. Their upper surfaces are dome shaped and exhibit rounded protuberances, while their bases are nearly horizontal. Cumulus fractus or fractocumulus resemble ragged cumulus in which the different parts show constant change.

4. Cumulonimbus (CB). Cumulonimbus (fig. 15-6(B)) are heavy masses of cumulus-type clouds, with great vertical development, whose cumuliform summits resemble mountains or towers. Tops may extend higher than 60,000 feet. Their upper parts are composed of ice crystals and have a fibrous texture; often they spread out in the shape of an anvil. Cumulonimbus are the familiar thunderclouds, and their precipitation is of a violent, intermittent, showery character. Hail often falls from well-developed cumulonimbus. These clouds also display on occasion several readily apparent supplementary features, such as (1) mamma or hanging protuberances, like pouches, on the under surface of the cloud; (2) tuba (commonly called the funnel cloud) resembling a cloud column or inverted cloud cone, pendant from the cloud base; and (3) virga, wisps or streaks of water or ice



A



B

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Figure 15-6. — Cloud examples (A) Cumulus (B) Cumulonimbus.

particles falling out of a cloud but evaporating before reaching the earth's surface as precipitation.

The Aerographer's Mate must learn to infallibly recognize the various cloud types as seen from the earth's surface.

In figure 15-7 there is a view of all types of clouds in a tier, each cloud type being shown at its average height.

Although one never sees all these types at any one time in nature, quite frequently two or three layers of clouds of different types may be observed simultaneously.

FOG

Fog may be defined as a cloud on the earth's surface; that is, visible condensation in the atmosphere of sufficient density to interfere with marine and aerial navigation. Fog varies in depth from a few feet to many hundreds of feet. Its density is variable, resulting in visibilities from near zero to several miles. It differs from rain or mist in that its water or ice particles are more minute and suspended, and do not fall earthward.

The forecasting of fog is frequently a difficult job. In addition to knowledge of the meteorological causes of fog formation, it is necessary to have a thorough knowledge of local geography and topography, for a slight air drainage may be enough to prevent fog formation, or a quick shift in the wind direction may cause fog to cover an airport.

The temperature to which air must be cooled, at a constant pressure and a constant water vapor content, in order for saturation to occur is the dewpoint. This is a variable, based upon the amount of water vapor present in the atmosphere. The more water vapor present, the higher the dewpoint. Thus, the dewpoint is really an index of the amount of water vapor present in the air at a given pressure.

The two manners in which the temperature and dewpoint may be made to coincide are as follows:

1. By raising the dewpoint until it equals the temperature.

2. By lowering the temperature to the dewpoint.

The first results from the addition of water vapor to the air by evaporation from water surfaces, wet ground, or rain falling through the air. The second results from the cooling of the air by contact with a cold surface underneath.

Types of Fog

There are several classifications of fog—radiation fog, advection fog, upslope fog, and frontal fog.

RADIATION FOG.—Radiation fog, which generally occurs as ground fog, is caused by the radiational cooling of the earth's surface. It forms only at night and over a land surface. It never forms over a water surface. This type of fog usually covers a wide area.

After sunset, the earth receives no heat from the sun, but it continues to radiate heat. The surface begins to cool because of this heat loss. As the earth cools, the layer of air close to the earth is cooled by conduction (the transfer of heat from warmer to colder matter by contact). This causes the layer near the earth to be cooler than the air immediately above it, a condition called an inversion. If the air beneath the inversion layer is sufficiently moist and it cools to its dewpoint, fog forms. (See fig. 15-8.) In case of a calm, this cooling by conduction affects only a very shallow layer (a few inches deep), because air is a poor conductor of heat. Wind of low speed (3 to 5 knots) causes slight, turbulent currents. This turbulence is enough to spread the fog through succeedingly deeper layers. As the nocturnal cooling continues, the air temperature drops further, more moisture is condensed, and the fog becomes deeper and denser.

After the sun rises, the earth is heated. Radiation from the warming surface heats the lower air, causing evaporation of the lower part of the fog, thereby giving the appearance of lifting. Before noon, heat radiated from the warming surface of the earth destroys the inversion, and the fog evaporates into the warmed air.

Radiation fog is common in high-pressure areas where the wind speed is usually low

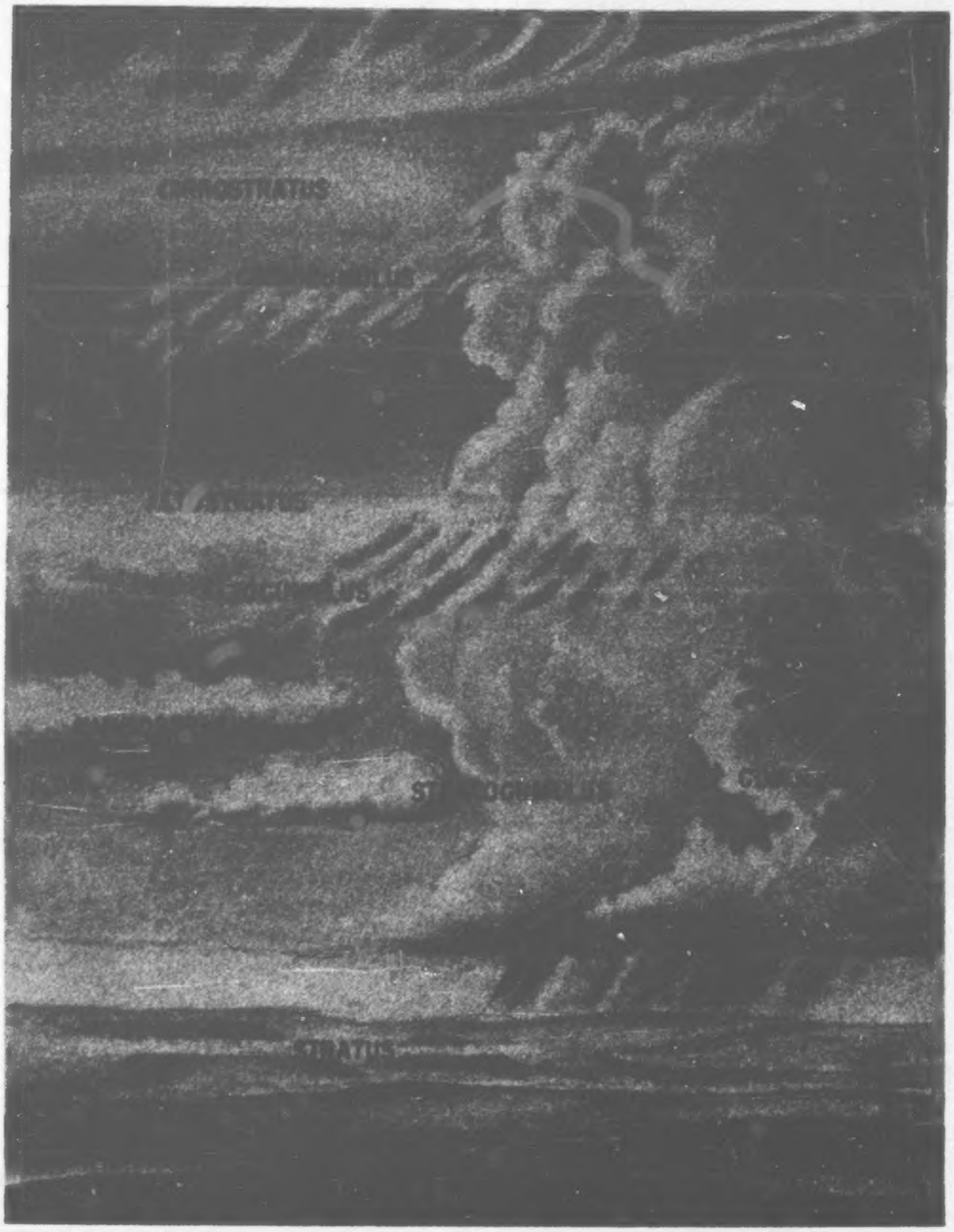
CIRROSTRATUS
STRATOCUMULUS
STRATUS

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Figure 15-7. — Layer diagram of clouds at various levels.

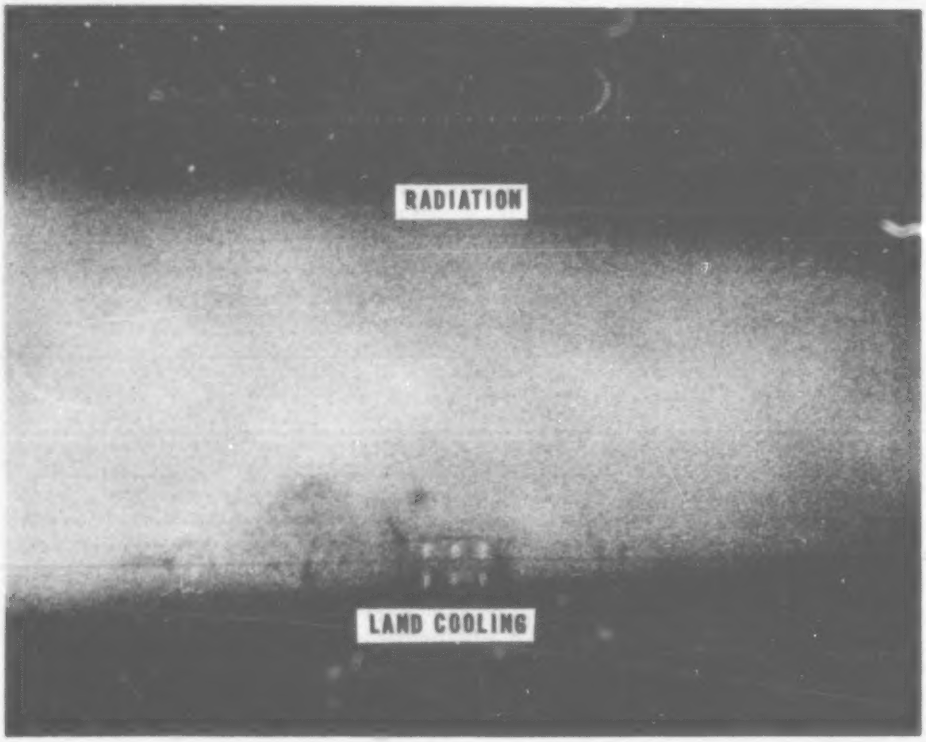

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Figure 15-8.—Radiation fog.

(2 to 5 knots) and clear skies are frequent. This permits maximum radiational cooling.

ADVECTION FOG.—Advection fog is the name given to fog produced by air in motion or to fog formed in one place and transported to another. This type of fog is formed when warmer air is transported over colder land or water surfaces. Cooling from below takes place and gradually builds up a fog layer. The cooling rate depends on the wind speed and the difference between the air temperature and the temperature of the surface over which the air travels.

Advection fog can form only in regions where marked temperature contrasts exist within a short distance of each other, and only when the wind blows from the warm region toward the cold region. (See fig. 15-9.) It is easy to locate areas of temperature contrast on the weather map. They are usually found along coastlines or between snow-covered and bare ground.

SEA FOG is always of the advection type and occurs when the wind brings moist warm air over a colder ocean current. The greater the difference between the air temperature and the ocean temperature, the deeper and denser the fog. Sea fog may occur during either the day or the night. Some wind is necessary, not only to provide some vertical mixing, but actually also to move the air to the place where it is cooled. Most advection fogs are found at speeds between 4 and 13 knots. Sea fogs have been maintained with wind speed as high as 26 knots. They exist at such speeds because of the lesser frictional effect over a water surface. Winds of equal speed produce less turbulence over water than over land.

Sea fogs, which tend to persist for long periods of time, are quite deep and dense. Since the temperature of the ocean surface changes very little during the day, it is not surprising

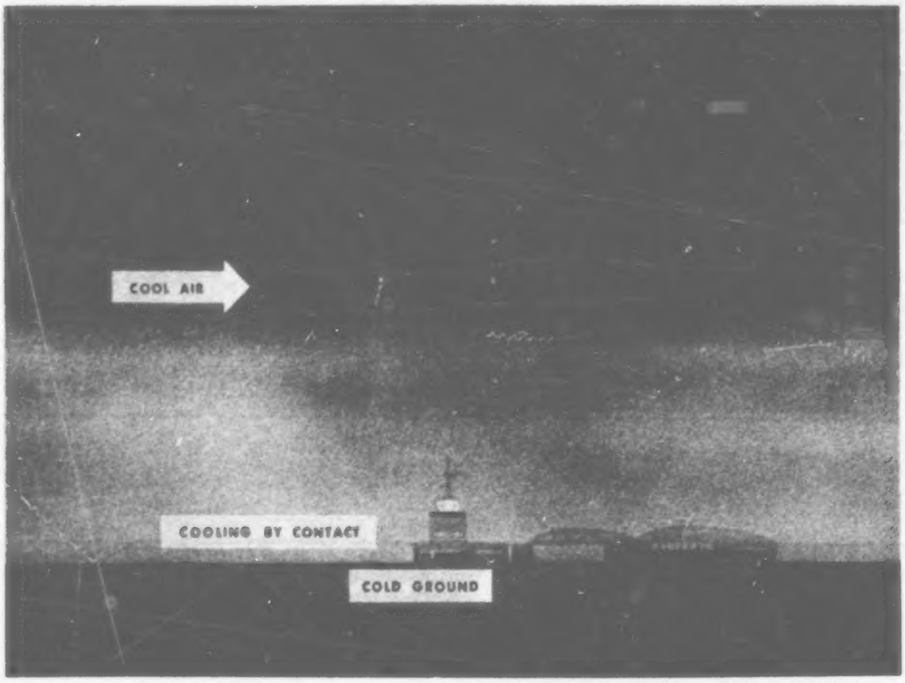

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Figure 15-9.—Advection fog.

to hear of sea fogs which have lasted for weeks. A good example of sea fog is that off the coast of Newfoundland.

LAND ADVECTION FOG is found near large bodies of water; that is, along seacoasts and large lakes. Onshore breezes bring maritime air over a land surface which has cooled by radiation at night. (See fig. 15-10.) Also, fogs may form over the ocean and be blown over the land, during either the day or the night. Another situation favorable to fog formation is one in which air flows from warm, bare ground to snow-covered ground nearby.

Land advection fog cannot exist with as high wind speed as the sea type because of the greater turbulence. If only a slight amount of cooling is necessary to cause condensation, even a cloud cover may permit the land surface to cool enough to cause fog. This type of fog dissipates over a land surface in much the same fashion as radiation fog; however, since it is usually deeper, it requires a longer time to disperse.

STEAM FOG, another type of advection fog, occurs within air masses; but, unlike other air-mass fogs, which are formed by the cooling of the air temperature to the dewpoint, steam fog is caused by saturation of the air through evaporation of water. It occurs when cold air moves over warm water. Evaporation from the surface of the warm water easily saturates the cold air, causing fog. It rises from the surface like smoke. It should be noted that the actual process, heating cold air over a warm surface, tends to produce instability. Deneness and persistence are favored by the presence of inversion above the surface, which prevents the fog from rising very high.

This type of fog forms on clear nights over inland lakes and rivers in late fall before they are frozen. They are prevalent along the Mississippi River and Ohio River at that time of year.

ARCTIC SEA SMOKE (name given to steam fogs in the Arctic region) forms when cold air moves over a warmer water surface, which is

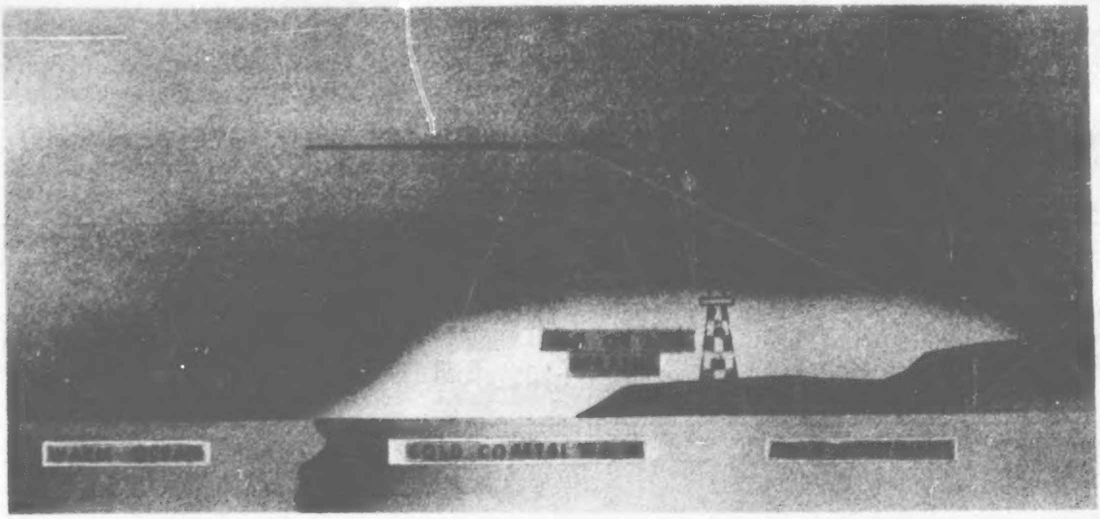


Figure 15-10.—Fog caused by an onshore wind and cold coastal water.

most often found in breaks of the surface ice in this area. It may also occur over the ocean surface following a cold frontal passage when the water is approximately 40°F warmer than air passing over it.

UPSLOPE FOGS.—There is a type of fog, called upslope fog, which is caused by adiabatic cooling of rising air (adiabatic cooling is the cooling of the air by expansion as it rises). Upslope fog is formed when moist, warm air is forced up a slope by the wind. The cooling of the air is almost entirely adiabatic, since there is very little conduction to the surface of the slope. The air must be stable before it starts its motion so that the lifting does not cause convection, or vertical currents, which would dissipate the fog.

Some wind speed is needed, of course, to cause the upslope motion. The fog is usually found where the air moves up a gradual slope. This type of fog is deep and requires considerable time to dissipate. The most common fog of this type is called CHEYENNE FOG and is caused by the westward flow of air from the Missouri Valley, which produces fog on the eastern slope of the Rockies.

FRONTAL FOGS.—Frontal fogs are another hazard which must be added to the list of weather troubles associated with fronts. The actual fog occurs under the frontal surface in the cold air mass. It is due to the evaporation of falling rain. This additional water vapor gradually saturates the air. Precipitation falls from the lifted warm air through the cold air. Evaporation from the rain continues as long as the temperature of the raindrops is higher than the temperature of the air, even though the cold air is already saturated. Naturally, the upper regions become saturated first because the temperature and dewpoint are lower at the higher altitude. As the evaporation from the rain continues, a layer of clouds begins to build down from the frontal surface. Eventually, this cloud layer extends to the ground and becomes fog. During the day, there may be enough turbulence caused by solar heating to keep this cloud off the ground. However, after dark, because of dying convection currents and the nocturnal cooling of the air, the ceiling drops very suddenly. It is this sudden closing in after dark that makes this type of fog so dangerous.

Cold fronts usually move so rapidly and have such narrow bands of precipitation and high wind speeds that COLD-FRONT FOG is comparatively rare and short lived.

WARM-FRONT FOG, on the other hand, is common and dangerous. Since frontal systems are quite extensive, warm-front fog may cover a wide area. This type fog is also very deep, because it extends from the ground to the frontal surface. The clouds above the frontal surface also slow down the dissipating effect of solar heating. All these factors make the warm-front fog the worst possible type to encounter. (See fig. 15-11.)

DEW

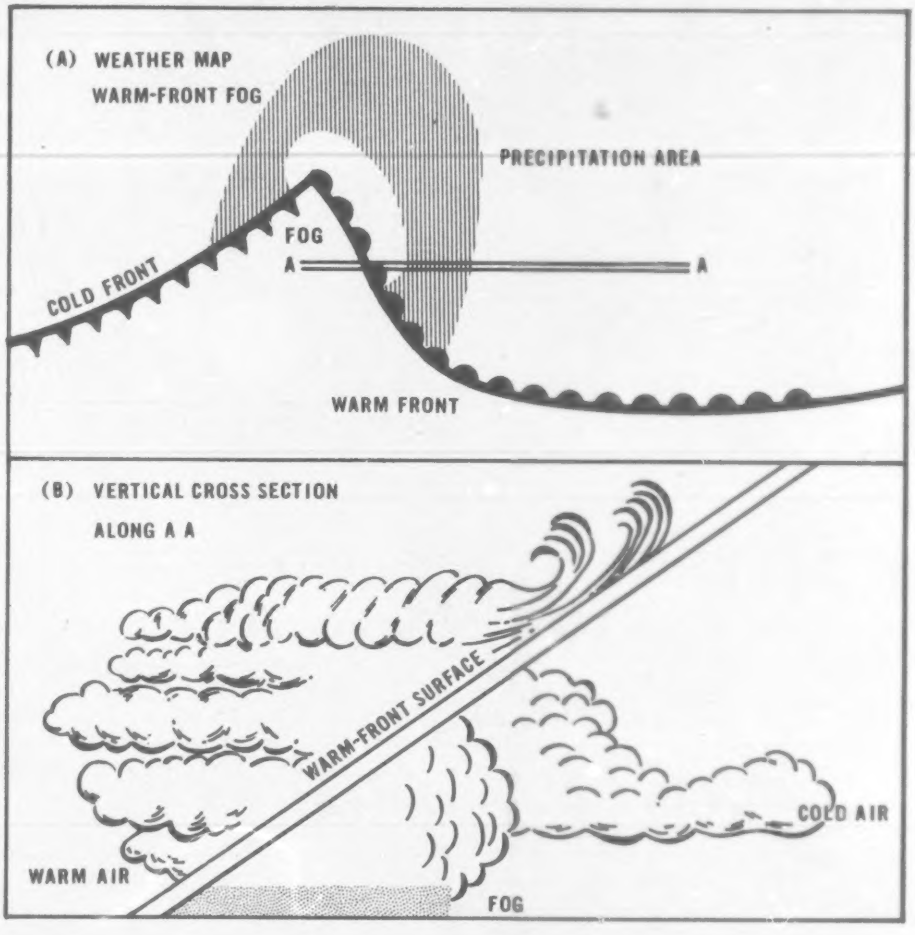
Dew is a deposit of waterdrops on objects at or near the ground. It is produced by condensation of water vapor from the surrounding clear air and occurs on relatively calm, clear nights.

White Dew

White dew consists of a deposit of white, frozen dew drops. It first forms as liquid dew, then freezes.

FROST

Frost, or hoarfrost, is a deposit of ice having a crystalline appearance. It generally assumes the form of scales, needles, feathers, or fans. Hoarfrost is the solid equivalent of dew and should not be confused with white dew, which is dew frozen after it formed. Frost


(A) WEATHER MAP
WARM-FRONT FOG
PRECIPITATION AREA
FOG
A
A
COLD FRONT
WARM FRONT
(B) VERTICAL CROSS SECTION
ALONG A A
WARM-FRONT SURFACE
COLD AIR
WARM AIR
FOG

209.31

Figure 15-11. — Warm-front fog.

forms as such directly without going through the liquid stage.

TORNADOES

A tornado is an exceedingly violent whirling storm with a small diameter, usually a quarter of a mile or less. The length of the track of a tornado on the ground may be from a few hundred feet to 300 miles; the average is less than 25 miles. When not touching the ground it is termed a "Funnel Cloud." Data from recent tornado studies indicate that the velocities of tornadic winds are in the general range of 150 to 300 miles per hour. A large reduction of pressure in the center due to the spiraling of the air seems to cause buildings in the path of the storm to explode. The speed of the storm over the earth's surface is comparatively slow—usually 25 to 40 mph.

Most of the tornadoes in the United States occur in the late spring and early summer, and are associated with thunderstorm activity and heavy rain. Tornadoes have been observed with various synoptic situations and usually are associated with overrunning cold air. Statistics show that the majority of tornadoes appear about 75 to 180 miles ahead of a cold front along the prefrontal squall line. Figure 15-12 shows the various stages of development of a tornado.

A situation that is noticeably favorable to tornado activity is cold air advection aloft. When mP air moves across the United States, it becomes heated in the low levels from the Western Plateaus. Having a density equal to or less than the mT air moving northward over the Mississippi Valley, the mP air rides up over the mT air. The mP air still maintains low temperatures at higher altitudes; this causes extreme instability.

The following conditions may indicate possible tornado activity:

1. Pronounced horizontal wind shear. (Wind shear is the rate of change of wind velocity with distance.)
2. Rapidly moving cold front.
3. Strong convergence.
4. Marked convective instability.
5. Dry air mass superimposed on a moist air mass. Abrupt change in moisture content, usually below 10,000 feet.

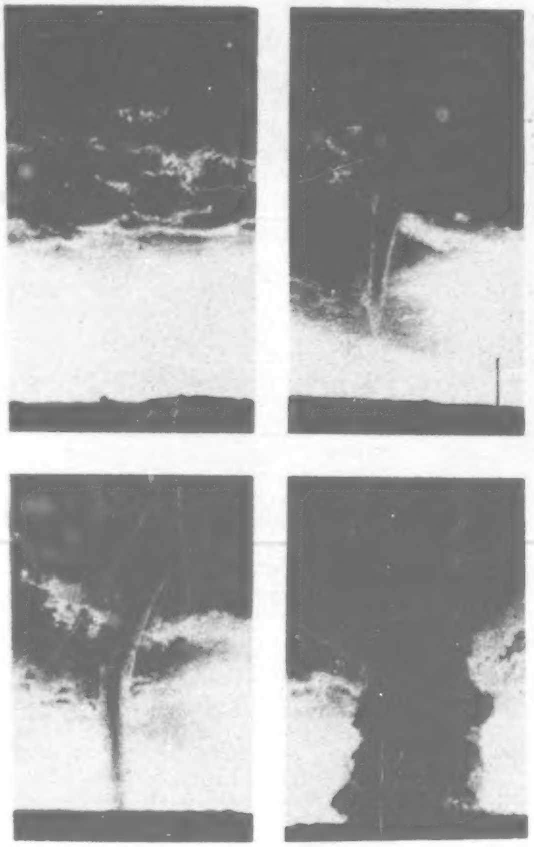


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Figure 15-12. —Stages of development of a tornado.

6. Marked convection to the minus 10°C isotherm.

WATERSPOUTS

Waterspouts are tornadoes that form over ocean areas. They may be divided into two classes. One is the true waterspout in which the vortex forms at the cloud and extends to the surface. This type occurs mainly in advance of a squall line. The second type, often called the pseudo-waterspout, originates just above the water surface and builds upward; this type is identical with whirling dust often seen on deserts.

LITHOMETEORS

Along with hydrometeors, due consideration must be given to lithometeors, since they affect the state of the atmosphere. Lithometeors comprise a class of atmospheric phenomena, among which dry haze and smoke are the most common examples. In contrast to a hydrometeor, which consists largely of water, a lithometeor is composed of solid dust or sand particles, or the ashy products of combustion.

HAZE

Haze is suspended dust or salt particles so small that they cannot be individually felt or seen by the unaided eye. They reduce visibility and lend a characteristic opalescent appearance to the air. Haze resembles a uniform veil over the landscape that subdues its colors. This veil has a bluish tinge when viewed against a dark background and a dirty yellow or orange tinge when viewed against a bright background.

Irregular differences in air temperature may cause a shimmering veil over the landscape. This is called optical haze.

SMOKE

Smoke is fine ash particles suspended in the atmosphere. When smoke is present, the disk of the sun at sunrise and sunset appears very red and during the daytime has an orange tinge. Smoke at a distance, such as from forest fires, usually has a light grayish or bluish color and is evenly distributed in the upper air.

DUST

Dust is finely divided solid matter, uniformly distributed in the air. It imparts a tannish or grayish hue to distant objects. The sun's disk is pale and colorless or has a yellow tinge at all periods of the day.

Blowing Dust

Blowing Dust consists of dust raised by the wind to moderate heights above the ground and restricting horizontal visibility to less than 7 miles. When visibility is reduced to less than 5/8 mile but not less than 5/16 mile it is classed as a duststorm and if less than 5/16 mile, a severe duststorm.

SAND

Fine particles of sand picked up from the surface by the wind and blown about in clouds or sheets constitute a troublesome lithometeor in some regions.

Blowing Sand

Blowing sand consists of sand raised by the wind to moderate heights above the ground reducing horizontal visibility to less than 7 miles. When the visibility is reduced to less than 5/8 mile but not less than 5/16 mile, it is classed as a sandstorm and if less than 5/16 of a mile, a severe sandstorm.

DUST DEVILS

Dust devils, phenomena of whirling, dust-laden air, are caused by intense solar radiation, which sets up a steep lapse rate near the ground. They are best developed on a calm, hot afternoon with clear skies, and in desert regions. As the intense surface heating sets up a steep lapse rate, a small circulation is formed when the surrounding air rushes in to fill the area of the rising warm air. This warm ascending air carries dust, leaves, and other small material to a height of a few hundred feet.

PHOTOMETEORS

The photometeors are any of a number of atmospheric phenomena which appear as luminous patterns in the sky. They constitute such phenomena as solar and lunar halos, solar and lunar coronas, rainbows, and fogbows. Photometeors are not active elements; that is, they generally do not cause adverse weather. However, they are related to clouds which do cause adverse weather. Thus, they help in describing the state of the atmosphere.

HALOS

A halo is a luminous ring around the sun or moon. When it appears around the sun, it is a solar halo; when it forms around the moon, it is a lunar halo. It usually appears whitish, but it may show the spectral colors (red, orange, yellow, green, blue, indigo, and violet) with the red ring on the inside and the violet ring on the outside. The sky is darker inside the ring than outside. Halos are formed by REFRACTION of light as it passes through ice crystals. This means that halos are almost exclusively associated with cirriform clouds. Refraction of light means that the light passes through prisms; that is, ice crystals which act as prisms. Some reflection of light also takes place.

Halos appear in various sizes, but the most common size is the small 22-degree halo. The size of the halo can be determined visually with ease. Technically, the radius of the 22-degree halo subtends an arc of 22 degrees. This simply means that the angle measured from the observation point between the luminous body and the ring is 22°. Halos of other sizes are formed in the same manner.

CORONAS

A corona is a luminous ring surrounding the sun (solar) or moon (lunar) and is formed by DIFFRACTION of light by water droplets. It may vary greatly in size, but is usually smaller than a halo. All the spectral colors may be visible, with red on the outside; but frequently the inner colors are not visible. Sometimes the spectral colors or portions of them are repeated several times and are somewhat irregularly distributed. This phenomenon is called iridescence.

RAINBOWS

The rainbow is a circular arc seen opposite the sun, usually exhibiting all the primary colors, with red on the outside. It is caused by diffraction, refraction, and reflection of light within raindrops, often with a secondary bow outside the primary one. In this case the colors are reversed. The colors of a rainbow are red to blue and violet.

FOGBOWS

A fogbow is a whitish semicircular arc seen opposite the sun in fog. Its outer margin has a reddish tinge; its inner margin has a bluish tinge. The middle of the band is white. An additional bow, with the colors reversed, sometimes appears inside the first.

ELECTROMETEORS

An electrometeor is a visible or audible manifestation of atmospheric electricity. The more important electrometeors are thunderstorms, lightning, and the auroras.

THUNDERSTORMS

An Aerographer's Mate must be cognizant of thunderstorm activity in order to advise pilots as to the best possible routes for flight. Since approximately 44,000 thunderstorms occur daily over the surface of the earth, a pilot will sometimes fly through a thunderstorm or a thunderstorm area. The turbulence within most thunderstorms is considered one of the worst hazards of flying.

Ground personnel also need to be advised as to the strong gusty surface winds that are often associated with the thunderstorm.

Much of the information about thunderstorms in this chapter is based on the findings of the Thunderstorm Project which was conducted at Orlando, Fla., and Wilmington, Ohio, as a joint project of the weather services of the Armed Forces and the National Weather Service.

Formation

The thunderstorm represents a violent and spectacular atmospheric phenomenon. The thunderstorm is usually accompanied by lightning, thunder, heavy rain, gusty surface wind, and frequently by hail. A certain combination of atmospheric conditions is necessary for the formation of a thunderstorm. These factors are conditionally unstable air of relatively high humidity and some type of lifting action. Before the air actually becomes unstable, it must be lifted to a point where it is warmer than the surrounding air. When this condition is brought about , the relatively warmer air continues to rise freely until, at some point aloft, its temperature has cooled to the temperature of the surrounding air. In order to bring the warm surface air to a point where it will continue to rise freely, some type of external lifting action must be introduced. Many conditions satisfy this requirement. For example, an air mass may be lifted by heating, terrain, and fronts or convergence.

Structure

The fundamental structural element of the thunderstorm is the unit of convective circulation known as a convective cell. A mature thunderstorm contains several of these cells, which vary in diameter from 1 to 6 miles. By radar analysis and measurement of drafts, it has been determined that, generally, each cell is independent of surrounding cells of the same storm. Each cell progresses through a cycle which lasts from 1 to 3 hours. In the initial stage (cumulus development), the cloud consists of a single cell; but as the development progresses, the new cells form and older cells dissipate.

The life cycle of the thunderstorm cell consists of three distinct stages; they are the cumulus stage, the mature stage, and the dissipating or anvil stage. (See fig. 15-13.)

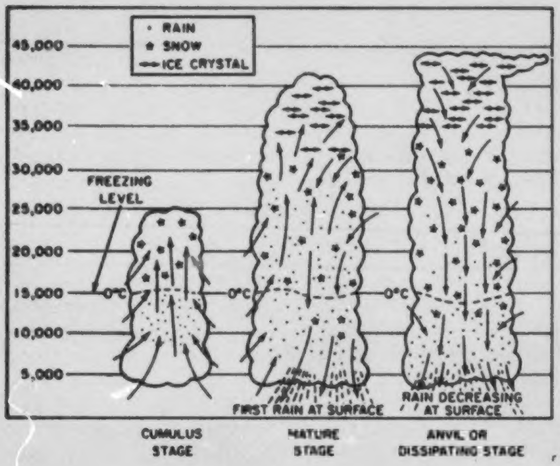

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Figure 15-13. — Life cycle of a thunderstorm cell.

CUMULUS STAGE. — Although most cumulus clouds do not become thunderstorms the initial stage of a thunderstorm is always a cumulus cloud. The chief distinguishing feature of this cumulus or building stage is an updraft, which prevails throughout the entire cell. Such updrafts vary from a few feet per second to as much as 100 feet per second in mature cells.

MATURE STAGE. — The beginning of surface rain, with adjacent updrafts and downdrafts, initiates the mature stage. By this time the apex of the average cell has attained a height of 25,000 feet or more. As the raindrops begin to fall, the frictional drag between the raindrops and the surrounding air causes the air to begin a downward motion. Since the lapse rate within a thunderstorm cell is more than the moist adiabatic rate, the descending saturated air soon reaches a level where it is colder than its environment; consequently, its rate of downward motion is accelerated. This is a downdraft.

A short time after the rain starts its initial fall, the updraft reaches its maximum speed. The speed of the updraft increases with altitude. Downdrafts are usually strongest at the middle and lower levels, although the variation in speed from one altitude to another is less than in the case of updrafts. Downdrafts are not as strong as updrafts; downdrafts speed ranges from a few feet per second to about 40 feet per second. Significant downdrafts seldom extend to the top of the cell because in most cases only ice crystals and snowflakes are present, and their rate of fall is insufficient to cause appreciable downdrafts.

The mature cell, then, generally extends far above 25,000 feet, and the lower levels consist of sharp updrafts and downdrafts adjacent to each other. Large water droplets are encountered suspended in the updrafts, and descending with the downdrafts as rain.

DISSIPATING (ANVIL) STAGE. — Throughout the life span of the mature cell, more and more air aloft is being dragged down by the falling raindrops. Consequently, the downdraft spreads out to take the place of the dissipating updraft. As this process progresses, the entire lower portion of the cell becomes an area of downdraft. Since this is an unbalanced situation, and since the descending motion in the downdraft effects a drying process, the entire structure begins to dissipate. The high winds aloft have now carried the upper section of the cloud into the anvil form, indicating that gradual dissipation is overtaking the storm cell.

Vertical Development

MEASUREMENT. — Thunderstorms have been accurately measured as high as 67,000 feet, and it is believed that some severe thunderstorms actually attain a greater height than this. More often the maximum height is from 40,000 to 45,000 feet. Air-mass thunderstorms in general extend to greater heights than frontal types.

DRAFTS AND GUSTS.—Rising and descending drafts of air are, in effect, the structural bases of the thunderstorm cell. A draft is a large-scale vertical current of air that is continuous over many thousands of feet of altitude. Speeds of the drafts are either relatively constant or gradually varying from one altitude to the next. Gusts, on the other hand, are smaller scaled discontinuities associated with the draft proper. A draft may be compared to a great river flowing at a fairly constant rate, whereas a gust is comparable to an eddy or any other random motion of water within the main current.

Thunderstorm Weather

RAIN.—Liquid water in a storm may be ascending if encountered in a strong updraft; it may be suspended, seemingly without motion, yet in extremely heavy concentration; or it may be falling to the ground. Rain, as normally measured by surface instruments, is associated with the downdraft. This does not preclude the possibility of a pilot entering a cloud and being swamped, so to speak, even though rain has not been observed from surface positions. Rain is found in almost every case below the freezing level. In instances in which no rain is encountered, the storm probably has not developed into the mature stage.

Statistics show, although heavy rain is generally reported at all levels of a mature storm, the greatest incidence of heavy rain occurs in the middle and lower levels of the storms.

HAIL.—Hail, if present, is most often found in the mature stage. Very seldom is it found at more than one or two levels within the same storm. When it is observed, its duration is very short. The maximum occurence is at middle levels for all intensities of hail. During Project Thunderstorm, hail was encountered at a maximum of 10 percent of the traverses at any given altitude. However, the area from which the data were taken is far removed from the region of the greatest surface hail, the Great Plains States.

SNOW.—The maximum frequency of moderate and heavy snow occurs several thousand feet above the freezing level. Snow, mixed in many cases with supercooled rain, may be encountered in updraft areas at all altitudes above the freezing level. This presents a unique icing problem—wet snow packed on the leading edge of the wing of the aircraft resulting in the formation of rime ice.

TURBULENCE.—There is a certain definite correlation between turbulence and precipitation. The intensity of associated turbulence, in most cases, varies directly with the intensity of the precipitation.

ICING.—Icing may be encountered at any level where the temperature is below freezing. Both rime and clear ice occur, with rime predominating in the regions of snow and mixed rain and snow.

Since the freezing level is also the zone of greatest frequency of heavy turbulence and generally heavy rainfall, this particular altitude appears to be the most hazardous.

SURFACE WIND.—A significant hazard associated with thunderstorm activity is the rapid change in surface wind direction and speed immediately prior to storm passage. The strong winds at the surface accompanying thunderstorm passage are the result of the horizontal spreading out of downdraft currents from within the storm as they approach the surface of the earth.

The total wind speed is a result of the downdraft divergence plus the forward velocity of the storm cell. Thus, the speeds at the leading edge, as the storm approaches, are greater than those at the trailing edge. The initial wind surge, as observed at the surface, is known as the FIRST GUST.

The speed of the first gust is normally the highest recorded during storm passage, and the direction may vary as much as 180 degrees from the previously prevailing surface wind. First-gust speeds increase to an average of about 16 knots over prevailing speeds, although gusts of over 78 knots (90 mph) have been recorded. The average change of wind direction associated with the first gust is about 40 degrees.

Classifications

All thunderstorms are similar in physical makeup; but for purposes of identification, they may be divided into two general groups—frontal thunderstorms and air-mass thunderstorms.

FRONTAL. — Frontal thunderstorms are most commonly associated with the warm and cold types of fronts.

The warm-front thunderstorm is caused when warm, moist, unstable air is forced aloft over a colder, denser shelf of retreating air. Warm-front thunderstorms are generally scattered; they are difficult to identify because they are obscured by other clouds.

The cold-front thunderstorm is caused by the forward motion of a wedge of cold air into a body of warm, moist, unstable air. Cold-front storms are normally positioned aloft along the frontal surface in what appears to be a continuous line.

Under special atmospheric conditions, a line of thunderstorms develops ahead of a cold front. This line of thunderstorms is known as a prefrontal squall line. Its distance ahead of the front ranges from 50 to 300 miles. Prefrontal thunderstorms are usually intense and appear very menacing. Bases of the clouds are very low. Tornadoes sometimes occur when this type of activity is present.

AIR MASS. — Air-mass thunderstorms are subdivided into several types. In this discussion, however, only two basic types are mentioned — the convective thunderstorm and the orographic thunderstorm.

CONVECTIVE. — Convective thunderstorms may occur over land or water almost anywhere in the world. Their formation is caused by solar heating of various areas of the land or sea, which, in turn, provides heat to the air in transit. The land type of convective thunderstorms normally forms during the afternoon hours after the earth has gained maximum heating from the sun. If the circulation is such that cool, moist, convectively unstable air is passing over this land area, heating from below causes convective currents and results in towering cumulus or thunderstorm activity. Dissipation usually begins during the early evening hours.

Storms that occur over bodies of water form in the same manner, but at different hours. Sea storms usually form during the evening after the sun has set. They dissipate during the late morning. An example that combines both types of convective thunderstorms is the situation that exists in Florida. Circulation around the Bermuda high transports moist air over the land surface of Florida during the entire day. The Bermuda high causes air to flow from the east over Florida. Thunderstorms off the east Florida coast at night are caused by warm air advection from the east wind and the warm axis of the Gulf Stream, aided by nocturnal cooling of air above sea level, setting up an unstable lapse rate. During the hours of sunlight, the land surface is considerably warmer than the air; consequently, the air is subjected to heating from below. Convective currents result, and the common afternoon thunderstorm is observed. After sundown, the earth loses its heat. Dissipation occurs, and the apparent movement of the storms to sea takes place. As the circulation causes air to flow over the peninsula at night, the air is cooled by the land surface. As this same air moves out over the warm water, it is heated from below, and cumulus activity occurs. Water, not being subject to such rapid temperature changes as land, retains much of the heat it has gained during the day. When the sun rises, the air over the sea surface becomes warmer than the surface, thereby destroying the balance necessary to keep a storm active, and dissipation occurs. As a general rule, convective thunderstorms are scattered and easily recognized. They are relatively high, and visibility is generally good in the surrounding area.

OROGRAPHIC. — Orographic thunderstorms form in mountainous regions, particularly adjacent to individual peaks. A good example of this type of storm occurs in the northern Rocky Mountain region. When the circulation of the air is from the west, moist air from the Pacific Ocean is transported to the mountains, where it is forced aloft by the upslope of the terrain. If the air is also conditionally unstable, this upslope motion causes thunderstorm activity on the windward side of the mountains. This activity may form a long, unbroken line of storms similar to a cold front. The storms persist as long as the circulation causes an upslope motion.

From the windward side of the mountains, identification of orographic storms may sometimes be difficult because the storms are obscured by other clouds. From the lee side, identification is positive; the outlines of each storm are plainly visible. Orographic storms, almost without exception, enshroud mountain peaks or hills.

Thunderstorm Detection

The information of upper air observations and the surface weather charts gives indications of thunderstorm activity. However, since these charts are normally prepared at 6- and 12-hour intervals, it is understandable that certain weather phenomena may form during the periods when observations for maps and upper air soundings are not scheduled.

Although a synoptic weather map gives definite indications of an approaching front or hurricane, or of the presence of thunderstorms in a specific area, minute-to-minute tracking of these weather phenomena is not possible. From the above-mentioned sources, the exact time of the occurrence of adverse weather is extremely difficult and, at times, impossible to forecast.

Radar has provided meteorology with an additional tool to be used in the collection of atmospheric data. It has been proved that reflection of radar pulses from precipitable water associated with clouds permits the continuous tracking of the position of such clouds with respect to the location of a station. Radar methods make it possible to forecast the approach of unfavorable weather with greater accuracy and with less difficulty than can be achieved by other methods.

It is beyond the scope of this training manual to discuss the relation between forecasting and radar in detail; however, one of the basic means of presentation should be mentioned—the PPI (Plan Position Indicator). The PPI scan is frequently employed where the tactical conditions require that range and bearing information be obtained concerning objects in or near a horizontal plane centered at the site of the radar station. Not only can the proximity of storms be ascertained, but also their speed, area, and development can be judged accurately by an experienced observer. Within the limitations of the radar equipment used with respect to range, precise short-range forecasts vital to the safety of personnel and equipment can be issued.

Destructive phenomena, such as the thunderstorm, can be detected, and their approach to the ship or station can be timed. In this manner, storm warnings can be given sufficiently early so that storm conditions may be set. With a radar range of 80 to 100 miles, a warning can be issued 5 to 6 hours prior to the arrival of a destructive storm traveling at a speed of less than 20 knots.

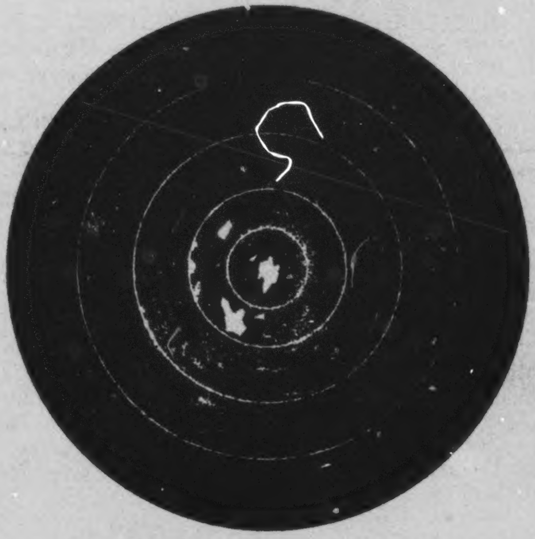

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Figure 15-14.—Radar echo of a thunderstorm.

The radar echo from a convective thunderstorm of a PPI scope is shown in figure 15-14. The radar was adjusted for a 25-mile range. The concentric lines are 5-mile markers. The bright area at azimuth 190 and the 8-mile range is a thunderstorm.

The weather map of an area in which convective thunderstorms are prevalent gives no defiite indication of the probability of a storm occurring at any given location. All that can be said, following a careful study of the weather map, is that the air in the vicinity of the ship or station is unstable and that thunderstorms will probably occur in the area. The storm picked up on the PPI scope in figure 15-14 did not appear on the weather map.

LIGHTNING

Lightning may be defined as a flash of light from a sudden electrical discharge which takes place between clouds or inside a cloud or from high structures on the the ground or from mountains. Four main types of lightning can be distinguished, as follows:

1. CLOUD TO GROUND LIGHTNING (CG). Lightning occurring between cloud and ground.
2. CLOUD DISCHARGES (IC). Lightning which takes place within the thunder cloud.
3. CLOUD TO CLOUD DISCHARGES (CC). Streaks of lightning reaching from one cloud to another.
4. AIR DISCHARGES (CA). Streaks of lightning which pass from a cloud to the air but do not strike the ground.

AURORAS

A luminous phenomenon which appears in the high atmosphere in the form of arcs, bands, draperies or curtains. This phenomenon is usually white but may have other colors. The lower edges of the arcs or curtains are usually well defined while the upper edges are not. Polar auroras are due to electrically charged particles, ejected from the sun, acting on the rarefied gases of the higher atmosphere. The particles are channeled by the earth's magnetic field, so that auroras are mainly observed near the magnetic poles. In the Northern Hemisphere they are known as aurora borealis; in the Southern Hemisphere they are known as aurora australis.

AIRGLOW

Airglow is similar in origin and nature to auroras; it, too, is an upper atmospheric electrical phenomenon. The main differences between airglow and aurora are that airglow is quasi-steady (quasi means seemingly) in appearance, is much fainter than aurora, and appears in the middle and lower latitudes.

CHAPTER 16

FUNDAMENTALS OF OCEANOGRAPHY

In previous chapters of this training manual information has been presented on a few of the oceanographic instruments which may be encountered by the Aerographer's Mate, including the rules to be followed when disseminating and recording the data after it was obtained. This chapter will discuss, briefly, some of the surface and subsurface properties of the oceans.

It should be remembered that just as a study of the entire surrounding atmosphere is necessary in meteorological forecasting, any serious study of the sea must also include ALL of the surface and subsurface elements of the environment. This is normally true even though only one or two of the many elements involved may be of use to the particular operation. The surrounding environment is going to have an effect on the elements being observed.

OCEANOGRAPHIC TERMINOLOGY

As with any scientific field of study, there are many oceanographic terms which the trainee will be unfamiliar with. Only a very few are included in the following paragraphs, since it is desired to confine the material to the basic fundamentals. Some of the terms which will be encountered in various sections of this chapter are as follows:

ABSORPTION.—When a sound wave travels outward from a source into the sea, some of the sound energy is converted into heat by friction due to molecular resistance of the water, thereby decreasing the intensity of the sound wave. This process is called absorption.

AIR-SEA INTERFACE.—The boundary between the atmosphere and the surface of the ocean.

AMBIENT NOISE.—Noise produced in the sea by waves, marine animals, ship and industrial activity, terrestrial movements, precipitation, and other underwater or surface activity.

ANGLE OF INCIDENCE.—The angle at which a ray of energy intersects a surface, measured between the direction of propagation of the energy (or object) and a perpendicular to the surface at the point of intersection, or incidence.

ARC.—The curved area of a ridge which rises above sea level.

ATTENUATION.—A general term applied to sound, referring to the loss of energy due to absorption and scattering.

BASIN.—A large depression in the ocean bottom of more or less circular or oval form.

BOTTOM SEDIMENTS.—Unconsolidated bottom materials; all naturally occurring unconsolidated matter which comprises the sea bottom and which consists of discrete particles of any size or origin.

BOTTOM WATER.—The water mass at the deepest part of the water column. It is the densest water that is permitted to occupy that position by the regional topography.

DEEP.—A depression in the ocean bottom exceeding 6,000 meters.

DEEP WATER.—The water mass normally found above bottom water. Deep water normally begins at the base of the main thermocline.

ISOHALINE.—Having no change in salinity along a given reference plane. (Equal salinity.)

ISOVELOCITY GRADIENT.—Values of sound velocity are the same in all parts of a given water column; no change in sound velocity with depth.

MIXED LAYER.—The layer of water which is mixed through wave action or thermohaline convection. Frequently, this is referred to as the layer.

MIXED LAYER DEPTH.—The depth of the bottom of the mixed layer. Frequently, this is referred to as the layer depth.

NEGATIVE TEMPERATURE GRADIENT.—A decrease in temperature with depth.

POSITIVE TEMPERATURE GRADIENT.—An increase in temperature with depth.

REFLECTION.—Sound rays transmitted in the sea eventually reach either the surface or the bottom. As these boundaries are abrupt and very different in sound transmitting properties from the water, sound energy along a ray path striking these boundaries will be returned (reflected) to the water.

REFRACTION.—The bending or curving of a sound ray that results when the ray passes obliquely from a medium of one velocity to a medium of another velocity. The sound wave will be bent toward the medium of lower velocity. When sound rays enter the layer of differing velocity perpendicular to the layer (90° angle of incidence), no refraction occurs.

REVERBERATION.—Sound from a source that has been scattered back towards the source, principally from the ocean surface (surface reverberation) or bottom (bottom reverberation), and from small scattering sources in the medium such as bubbles of air and suspended solid matter (volume reverberation).

RISE.—A long broad elevation rising gently from the ocean bottom.

SALINITY.—The salinity of sea water represents the total amount of dissolved solid material (in grams) contained in one kilogram (1,000 grams) of water. It usually is expressed in parts per thousand (‰).

SCATTERING.—The random dispersal of sound energy after it is reflected from the sea surface or bottom and/or off the surface of solid, liquid, or gaseous particles suspended in the water.

SEAMOUNT.—A submerged, isolated, mountainlike structure rising from the ocean bottom.

SHADOW ZONE.—A region into which very little sound energy penetrates.

SILL.—A submerged elevation separating two basins.

SILL DEPTH.—The greatest depth at which free horizontal exchange of matter between basins can take place.

SOUND VELOCITY.—In sea water, the rate of propagation of sound energy as a function of temperature, salinity, and pressure.

SURFACE DUCT.—Where the sound velocity at some depth near the surface is greater than at the surface, sound rays are refracted toward the surface where they are reflected. The rays alternately are refracted and reflected along the duct to considerable distances from the sound source.

THERMOCLINE.—The layer in the sea where the temperature decreases rapidly with depth.

TRANSPARENCY.—The ability of water to transmit light or be seen through.

TRENCH.—A long narrow depression in the ocean bottom having steep sides.

T-S DIAGRAM.—(Temperature-Salinity diagram.) The plot of temperature versus salinity data of a water column. It identifies the water masses in the column and indicates the stability of the water column.

VELOCITY GRADIENT.—The rate of change of sound velocity with depth in the ocean.

VISCOSITY.—The resistance of a substance to flow or be moved; viscosity is higher in cold water than in warm water.

WATER MASS.—A body of water having a distinct range of temperature and salinity. It is defined by a portion of a T-S curve. It usually consists of a mixture of two or more water types.

WATER TYPE.—Sea water of a single temperature value and a single salinity value, and hence defined by a single point on a temperature-salinity (T-S) diagram. Water types form at the sea surface in areas of constant climatic conditions.

SUBMARINE TOPOGRAPHY

In prior chapters of this manual it has been mentioned that the physical shape of land masses (mountains, valleys, etc.) above sea level has an important effect on the characteristics of the surrounding atmosphere. This is also true of the topography of the ocean floor. The irregular terrain of the ocean floor affects the characteristics of the sea in varying degrees, such as the movement of ocean water, the reflection of sound from the ocean floor, variations in temperature gradients due to the channeling and entrapment of water masses, etc.

As shown in figure 16-1, the ocean floor consists of mountains and valley features in the same manner that terrain above sea level does.

There are many divisions and subdivisions of classifications of ocean relief features. However, three of the more commonly used classifications are the continental shelf, the continental slope, and the ocean basins. They are described as follows:

CONTINENTAL SHELF

The continental shelf extends outward from the coast to a depth of 100 fathoms. The width of the shelf varies from zero in areas where the coast drops rapidly, to a maximum of about 800 miles along the glaciated coast of Siberia, with an average width of about 30 miles. (See fig. 16-1.) The continental shelf comprises about 7.5 percent of the total ocean bottom. The shelf region is a transition zone between fresh water runnoff from land and the more saline waters of the sea; consequently it is an area of great mixing of water with generally unstable water conditions. In the continental shelf region it is common for the currents to run parallel to the shore line.

CONTINENTAL SLOPE

The continental slope extends outward from the seaward end of the continental shelf to a depth of 1,500 fathoms. The continental slopes of the world comprise about 12 percent of the oceanic area. A slope resembles a terrestrial cliff that has been eroded by heavy rains, with the most striking features being the prevalence of submarine canyons, some equal in size to the Grand Canyon. A portion of the continental slope is indicated west of the Kuril Trench near Japan in figure 16-1.

OCEAN BASINS

The ocean basins range in depth from 1,500 fathoms at the end of the continental slopes to 3,000 fathoms at the deepest part of the ocean. The area of the basin is clearly delineated in figure 16-1. The Eastern portion of the figure, between the continental slope off the West Coast of U. S. to the Hawaiian Ridge, marks the boundaries of the Eastern Basin. The Western Basin lies between the Hawaiian Ridge and the continental slope off Japan.

About 80 percent of the ocean floor is a basin, having very rugged relief features ranging from ridges to trenches and deeps. Less than 1 percent of the oceanic area may be called a "deep" as defined earlier in this chapter.

PHYSICAL PROPERTIES OF SEA WATER

A convenient method of visualizing the sea is to divide it into layers in much the same way that we do the atmosphere. The term applied to this concept is the "three-layered ocean." The divisions of the ocean in accordance with this concept are illustrated in figure 16-2.

A general description of the three principal layers is as follows:

1. The mixed layer—a region of fairly constant warm (15° C) temperatures which in middle latitudes exist from the surface to a maximum depth of about 1,500 feet. In this layer the mixing of water is caused by action of thermohaline circulation, surface storms, wind friction, and wave action. Below the mixed layer, no matter how violent the storm, very little mixing will occur.

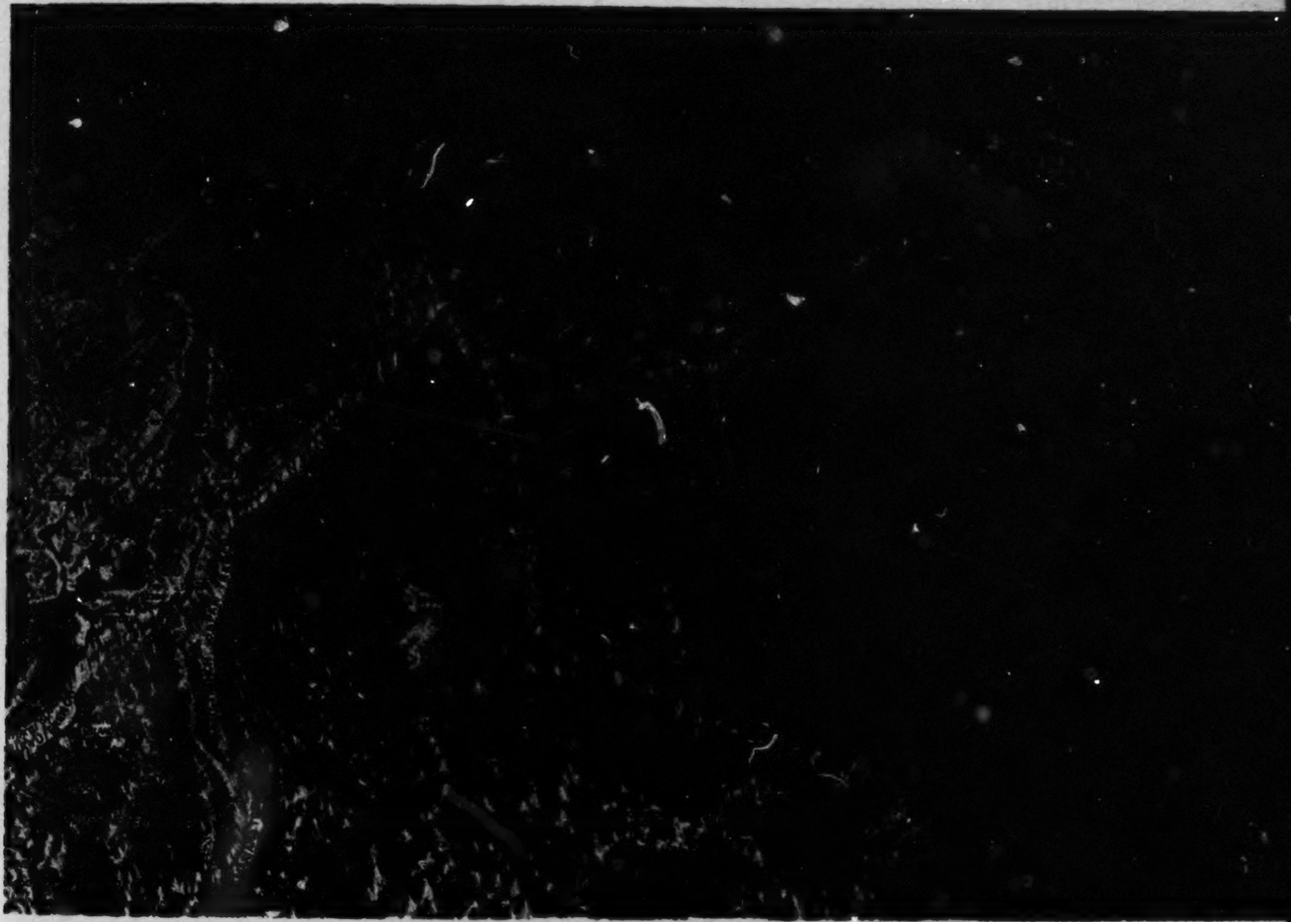

Figure 16-1.—The ocean floor of the North Pacific Ocean. Used by permission of National Geographic Soci

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—The ocean floor of the North Pacific Ocean. Used by permission of National Geographic Society.

2. The main thermocline—the central layer of the oceans in which there is a rapid decrease of water temperature with depth.

3. The deep layer—the bottom layer of water which in mid latitudes exists below 4,000 feet. The deep layer is characterized by fairly constant cold temperatures, generally less than 4° C.

We will now consider the physical properties of these layers, how they are determined, and their ranges and variations.

Two variables—temperature and pressure—determine the physical properties of pure water. When studying sea water, a third variable—salinity—must be considered.

It can readily be seen that some physical properties of sea water are dependent upon pressure, temperature, and salinity, while other properties are affected by the suspension of minute matter and motion characteristics. The latter variable cannot be accurately measured; whereas pressure, temperature and salinity can be determined with a greater degree of accuracy.

TEMPERATURE

About three-fourths of the earth's atmosphere is underlain by the water surfaces of the oceans and other bodies of water. It is the temperature of the sea water, primarily in the upper portions of the mixed layer, which has such a marked effect upon the atmospheric and climatic conditions over the surface of the earth.

The transport of heat from lower to higher latitudes takes place partly by air currents (winds) and partly by ocean currents.

Temperatures of the oceans will range from about -2° C to 30° C near the surface. There are of course variations dependent upon such factors as ocean currents, the character of the atmospheric circulations, latitude, variation of the amount of heat absorbed at different depths, and the effect of vertical motion.

Figure 16-2, depicting the three-layered ocean concept, illustrates the average vertical temperature distribution in middle latitudes, showing little temperature change through the mixed layer, sharp decrease through the thermocline layer, and a return to a gradual decrease in temperature through the deep water layer. In the lower latitudes, the mixed layer extends to approximately 300 feet, increasing to approximately 1,500 feet in middle latitudes and decreasing to less than 50 feet in higher latitudes. (See fig. 16-3.) The lack of mixed layer thickness at higher latitudes is a result of surface cooling and a sinking of water to deep or bottom layers.

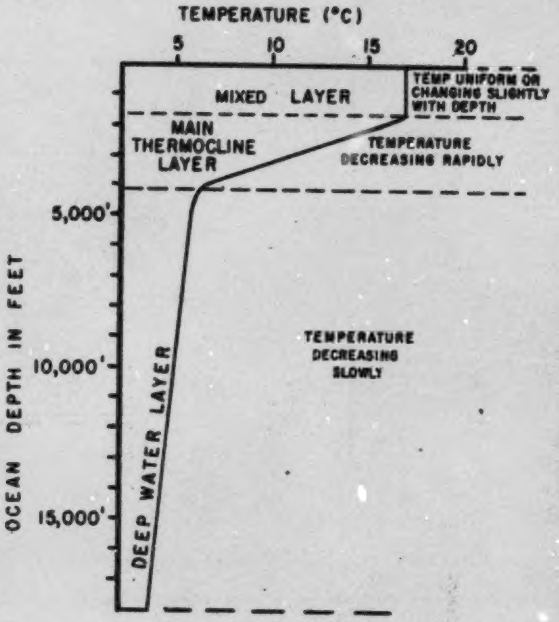

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Figure 16-2.—Typical thermal structure of the oceans (winter conditions in mid-latitudes).

SALINITY

The term "salinity" as defined earlier refers to the quantity of dissolved solid material in sea water.

Salinity in the open ocean varies between the limits of 33 to 37 ‰. Variation in surface salinity depends upon the ratio of evaporation to precipitation. In areas of excess evaporation, salinity is high; and in areas where precipitation is excessive, salinity values are low.

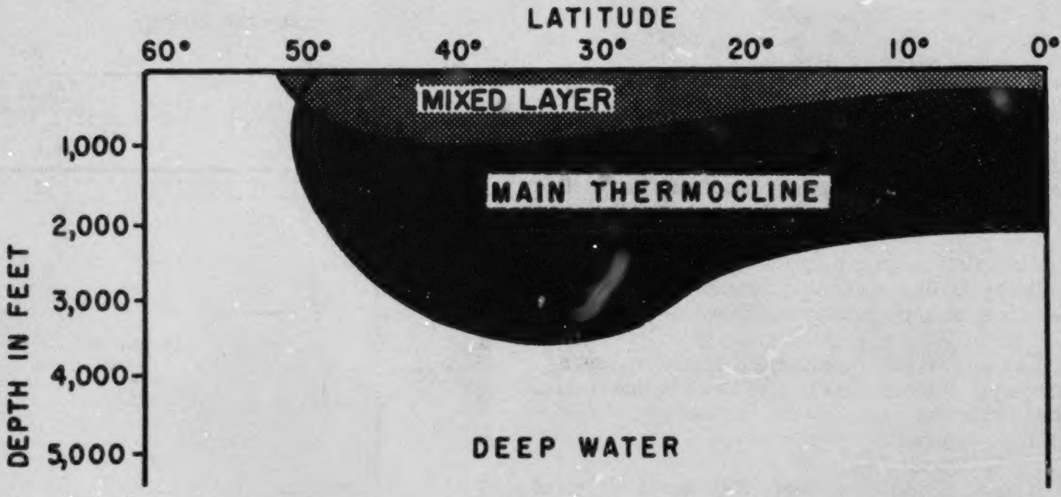

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Figure 16-3.—North-south distribution of a simple three-layered ocean (North Atlantic) in winter.

Areas in which precipitation or evaporation dominate vary with latitude and with seasonal changes.

Latitudinally a salinity minimum exists near the equator where precipitation is abundant, increasing to a salinity maximum near 20° latitude N and S where evaporation far exceeds precipitation. Salinity decreases again toward the polar seas where heavy precipitation and the fresh water inflow from melting ice and river runoff cause a minimum.

Greatest evaporation occurs when the air mass is colder than the underlying water; therefore on a seasonal basis, surface salinity values are higher in early spring and lower in late fall.

PRESSURE

The pressure of sea water is measured in terms of decibars. A decibar is one-tenth of a bar. As mentioned in chapter 12, a bar is 1 million dynes per square centimeter.

Pressure in the oceans is essentially a function of depth, with a 1-meter increase in depth equal to a 1-decibar increase in pressure. The numerical value of pressure in decibars is equal to the water depth in meters. Therefore, the range in pressure is from zero at the surface to over 10,000 decibars in the deepest part of the ocean.

DENSITY

As has been mentioned previously in this manual, density refers to mass per unit volume. The density of sea water is usually expressed in grams per cubic centimeter. Density is dependent upon temperature, salinity, and pressure.

Density increases when the salinity or pressure increases, but it decreases when the water expands with increasing temperature. When these properties are known, the density can be determined readily from standard density tables.

Under given conditions of temperature and pressure, ocean waters that have the greatest salinity also have the greatest density. Consequently, these waters have a tendency to sink. Since sea water is slightly compressible, as a mass of water sinks, the temperature of the mass increases adiabatically without an actual gain of heat. This occurs in the same manner as is observed in a parcel of air that is brought from a higher elevation to a lower elevation with a consequent adiabatic increase in temperature due to greater pressure. Pressure increases with depth because of the weight of the water above. Water will sink only when its density is greater than the density of the surrounding water. In the Tropics as the water is heated it decreases in density. It then expands and spreads northward and southward along the surface, gradually cooling as it approaches higher latitudes. As the warm surface water moves outward away from the Tropics, it is replaced by underlying cold water that flows in underneath from the polar regions. Thus, it is apparent that the deep water of all oceans is ultimately derived from high latitudes, and has much the same characteristics of salinity and temperature as the surface waters of those regions. Water types and masses are discussed later in this chapter.

SOUND TRANSMISSION QUALITIES

The most common form of energy presently used for the detection of subsurface craft is underwater sound. Being concerned with underwater sound transmission, we must be aware of the methods by which sound is generated, transmitted, lost, and received so we can better prepare forecasts of sound propagation conditions.

Refraction

Variations in the temperature and salinity of sea water can profoundly affect sound transmission because they produce variation in the speed of sound as it travels from one point to another. This, in turn, causes refraction of sound waves.

Sound waves travel in straight lines only in a medium in which the speed is everywhere constant. In sea water the speed of sound generally varies with depth. Suppose, for example, the speed increases with depth. In that case every ray of the sound beam will be curved toward the surface. This bending of the sound rays is REFRACTION. (See figs. 16-4 and 16-5.)

The degree of refraction is proportional to the velocity gradient so that a rapid increase in velocity with depth will refract the sound beam sharply toward the surface, while slight positive velocity gradients will cause the beam to bend over a longer arc.

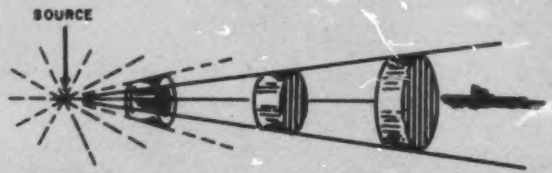

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Figure 16-4.--Outgoing ping showing shape of beam pattern and divergence of sound rays.

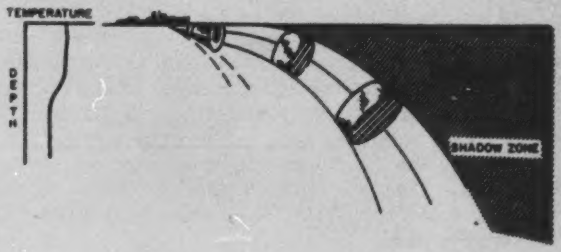

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Figure 16-5.—Drawing of outgoing ping showing effect of refraction.

Reflection

Sound energy striking some solid surface may be reflected as a mirror reflects light with little loss of intensity, may be scattered in many directions, or may be lost by absorption into the medium.

The surface of the sea is rarely smooth; therefore, sound energy striking it is seldom reflected specularly (mirror reflection). Instead, only minute elements of the sea surface reflect sound as a mirror; however, because the orientation of each of these "mirrors" is changing continuously, the sound energy is reflected in many directions.

Because of the acoustic property differences between air and water, almost all sound energy is reflected at the air-sea interface.

The ocean bottom also may reflect sound; however, the amount of sound energy reflected from the bottom depends upon the type of bottom material. A smooth sand bottom reflects sound very effectively. In contrast, a soft mud bottom is an especially poor reflector.

A smooth rock bottom is perhaps the best reflector because the amount of energy absorbed is small. In most areas, rock bottoms are irregular and, consequently, reflect sound in many directions. Much of the reflected energy is scattered back to the sound source, creating possible interference and consequent masking of the target signal. This type of interference is referred to as "reverberation."

Reverberation

If the surface and bottom of the ocean were absolutely smooth and no suspended matter (including fish) were in the water, there would be no reverberation. However, irregularities in the ocean surface, bottom, and the water itself are capable of scattering the sound pulse and echoes. That portion of the scattered sound which returns to the sound source is reverberation.

Attenuation

Sound energy propagated through a volume of sea water undergoes some loss of energy because of a factor referred to as "attenuation"; that is, absorption and scattering. In the passage of sound through water, some of the energy is converted into heat; this is called absorption. Scattering loss results from reflectors in the water that may vary in size from minute air bubbles to a whale.

MAJOR OCEANOGRAPHIC PARAMETERS

Many parameters (measurements) must be considered when attempting to present a complete picture of the ocean environment. It would be beyond the scope of this training manual to attempt to discuss all of them. However, some of these parameters are of more interest than others, depending upon their intended use. From a military viewpoint, among the more important parameters to be considered are the sea surface temperature (SST), the mixed layer depth (MLD), and the subsurface temperature gradients. The decoding, plotting, and analysis of this information were discussed in chapter 10 of this manual.

SEA SURFACE TEMPERATURES

Sea surface temperature (SST) observations are plotted on charts and analyzed to depict the relative warm and cold areas of the sea surface. SST charts provide fundamental information for the conversion of environmental data into operational data of concern to the Antisubmarine Warfare (ASW) and other interested users. This information may be in the form of sonar range predictions for ASW tactics or recommendations on more favorable convoy routes. Fog may be forecast to develop or dissipate on the basis of the SST pattern (air-sea temperature difference).

In search and rescue (SAR) operations, the SST chart is useful in indicating survival or operating time in water of differing temperatures. (See table 16-1.) SST charts may be used in conjunction with layer depth charts when determining the depth at which submarines may or may not be detected readily and areas in which sonar ranging may be restricted or enhanced.

MIXED LAYER DEPTH

The concept of the "three-layered ocean" was mentioned earlier in this chapter. The mixed layer, the main thermocline, and the deep layer were mentioned at that time. Of these three layers, the mixed layer is the most variable in its properties (primarily depth), and therefore demands considerable attention.

Variation in the depth of the mixed layer may occur as a result of several different factors; for example, day-to-day (diurnal) heating and cooling. Under extreme conditions these may have magnitudes of as much as 3° C. Usually, the day-to-day variation averages about 0.5° C. This is due to heating during the day, and this additional thermocline of a diurnal nature will probably occur within 30 feet of the surface with a maximum gradient occurring during the late afternoon. These conditions may sometimes result in what is referred to as the "afternoon effect." This is the solar heating of the surface water, which causes a shallow negative temperature gradient.

The net result of this condition is downward refraction of sound rays and reduction in near surface ranging.

Table 16-1.—Seawater survival times

Water Temp (°F)	Exhausted or Unconscious	Expected Survival Time
32.5	Less than 15 minutes	Less than 15 to 45 minutes
32.5 - 40.0	15-30 minutes	30-90 minutes
40.0 - 50.0	30-60 minutes	1 - 3 hours
50.0 - 60.0	1 - 2 hours	1 - 6 hours
60.0 - 70.0	2 - 7 hours	2 - 40 hours
70.0 - 80.0	3 - 12 hours	3 hours - indef
> 80.0	indefinite	indefinite

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Mixed layer depth (MLD) varies most on a seasonal cycle; not because of the season itself, but because of weather patterns which are associated with seasons. These weather patterns are the primary cause of "mechanical mixing."

Mechanical Mixing

Mechanical mixing is the indirect result of wind stress on the surface of the water. With the exception of areas where frequent advection of different water types occurs, mechanical mixing is the major process in formation of the mixed layer during the spring, summer, and fall. Mechanical mixing falls into three classifications: Advection, convergence and divergence.

ADVECTION.—In areas where vertical boundaries exist, such as the boundary between a cold current and a warm current, tongue-like protrusions of warm water under cold water or cold tongues over warm water create unstable water conditions.

DIVERGENCE AND CONVERGENCE.—Divergence occurs where the wind blows surface water out of an area, which happens with an off-shore wind. This diverging water is replaced by water from below through a process known as "upwelling". This upwelling of water which is always associated with divergence is a form of vertical mixing which decreases the depth of the mixed layer. Convergence of water occurs when wind causes surface water to pile up in an area. This piling up of water causes a sinking action which increases the depth of the mixed layer. Convergence of water normally occurs in areas of anti-cyclonic wind circulation while divergence is associated with cyclonic wind circulation. Convergence and divergence also occur where water masses or currents converge or diverge. In winter, mechanical mixing has little or no effect on the mixed layer since all mixing is caused by density increases in the surface layer. This type of mixing is referred to as "Instability Mixing".

INSTABILITY MIXING.—Instability mixing occurs when the uppermost layer of water becomes more dense than the underlying water, causing it to sink. This condition is set up by two processes called conduction and evaporation:

CONDUCTION.—This is a process where one surface comes in contact with another and an energy transfer is made. In winter, cold air masses invade the warmer ocean areas causing the surface of the sea to cool. This cooling sets up a vertical thermohaline circulation in the water mass resulting in an increase in the depth of the mixed layer.

EVAPORATION. — Evaporation causes the surface water to lose water vapor and heat. As the water vapor escapes into the atmosphere, the solids are left behind in the uppermost layer of water. This situation causes the uppermost layer of water to become more dense than the underlying water. This sets up vertical density currents resulting in an increase in the mixed layer depth. Evaporation is the most effective cooling process and the single most important factor in "instability mixing" of sea water. Instability mixing of sea water results from an increase in density and salinity which is produced by evaporation.

TEMPERATURE GRADIENT

Temperature gradient refers to the rate of temperature change with distance. Vertical gradients refer to changes with depth, and horizontal gradient refers to changes along a horizontal plane. Within a given water mass vertical gradients are most important, while at the boundaries between water masses or currents, horizontal gradients are significant.

The gradient is called positive if the temperature increases with depth; negative if it decreases. The temperature gradient is of considerable interest to the forecaster since it is the primary factor considered when determining the quality of sound transmission.

With a zero gradient, the sound rays are very nearly straight, having only a slight upward curvature due to the effect of pressure.

With a strong negative temperature gradient from the surface downward, the sound beam will curve down in an arc, creating a shadow zone into which very little sound penetrates except by scattering. In this case, an echo ranging vessel may not be able to detect a target located in the shadow zone. However, as soon as the target comes within the direct beam, the echoes will come in loud and clear. This is the situation illustrated in figures 16-4 and 16-5 in which the submarine in figure 16-4 is in the direct beam and the one in figure 16-5 is in the shadow zone.

In the ocean it is relatively common to find a mixed layer overlying a negative temperature gradient. In such cases the echo range on a target in the mixed layer will be long, but the part of the sound beam that enters the negative gradient will be refracted downward, resulting in reduction of range. With slighter negative temperature gradients and generally with any gradient underlying a mixed layer, the shadow zone will not be clearly defined.

SOUND RAY TRANSMISSION PATHS UNDER WATER

Before the Aerographer's Mate can correctly analyze the conditions under which a sound beam (packet of acoustic energy) will be received as an intelligible signal after it has been transmitted through the various mixtures of sea water, he must be able to determine the paths that the sound rays are likely to take. This includes determining energy loss due to reflection, absorption, and spreading along the way.

Snell's Law

In order to determine underwater ray paths, you should realize that sound rays will always bend in the direction of minimum sound velocity. This is the fundamental principle of sonar range prediction and is derived from SNELL'S LAW.

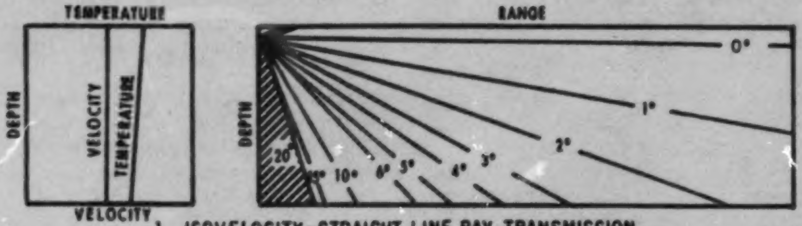
Based on Snell's law, the ray path of sound in water will refract upward if the velocity of sound increases with depth. The ray path will refract downward if the velocity of sound decreases.

Basic Sound Ray Patterns

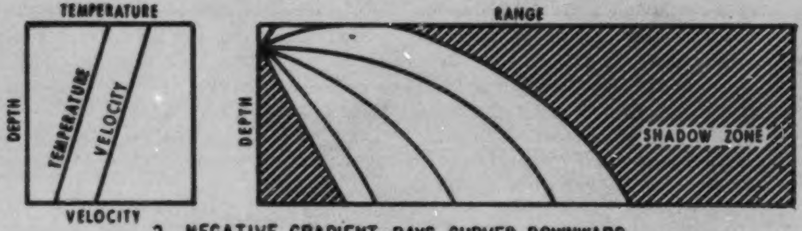
Figure 16-6 illustrates some of the basic patterns which might be encountered in the transmission of sound rays.

A brief discussion of the basic patterns shown in figure 16-6 is as follows:

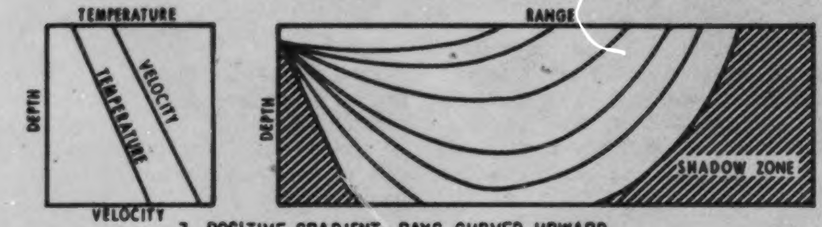
1. Straight line rays. This example shows a very slight negative temperature pattern as indicated by the sample bathythermogram trace at the left side of the figure (decrease of about 0.2°/100 feet of depth) which results in an isovelocity (no change in velocity) structure. The corresponding sound pattern shows rays leaving the sound source in straight lines which show very little change in the angle as the


TEMPERATURE
DEPTH
VELOCITY
TEMPERATURE
VELOCITY
RANGE
DEPTH
0°
1°
2°
3°
4°
5°
6°
10°
15°
20°

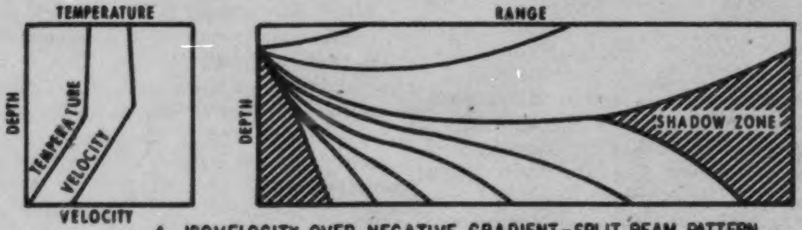
1. ISOVELOCITY-STRAIGHT LINE RAY TRANSMISSION


TEMPERATURE
DEPTH
TEMPERATURE
VELOCITY
VELOCITY
RANGE
DEPTH
SHADOW ZONE

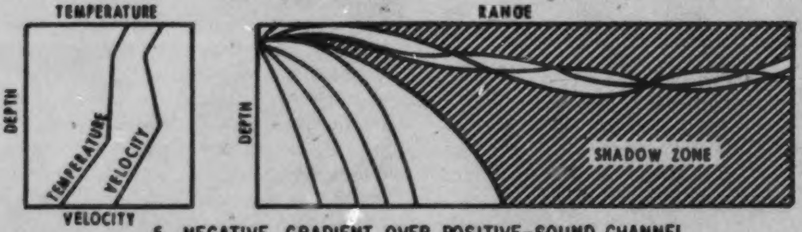
2. NEGATIVE GRADIENT-RAYS CURVED DOWNWARD


TEMPERATURE
DEPTH
TEMPERATURE
VELOCITY
VELOCITY
RANGE
DEPTH
SHADOW ZONE

3. POSITIVE GRADIENT- RAYS CURVED UPWARD


TEMPERATURE
DEPTH
TEMPERATURE
VELOCITY
VELOCITY
RANGE
DEPTH
SHADOW ZONE

4. ISOVELOCITY OVER NEGATIVE GRADIENT-SPLIT BEAM PATTERN


TEMPERATURE
DEPTH
TEMPERATURE
VELOCITY
VELOCITY
RANGE
DEPTH
SHADOW ZONE

5. NEGATIVE GRADIENT OVER POSITIVE-SOUND CHANNEL

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Figure 16-6.—Representative sound patterns based on temperature gradient.

distance increases from the source. Long ranges are possible when this type of structure prevails.

2. Rays curved downward. A negative temperature gradient (temperature decreasing with increasing depth) produces a negative velocity structure, which is a common occurrence near the sea surface. The sound rays transmitted from a source near the surface are bent sharply downward resulting in extremely short ranges when there is a rapid decrease of temperature. Beyond this range, a shadow zone occurs at the surface in which, theoretically, sound intensity is negligible. The sharpness of the temperature gradient determines the spread of the sound beam. For example, if the decrease in temperature to about 30 feet totals a degree or more, most of the sound beam would miss a shallow target located at a range of 1,000 yards.

3. Rays curved upward. A positive temperature gradient causes a sound velocity increase with increasing depth, and sound rays are refracted upward. Longer ranges are attained with this temperature structure than with a negative gradient because the rays are refracted upward from greater depths. Unless the sea surface is very rough, most of the rays are repeatedly reflected at the surface to longer ranges.

4. Split-beam pattern. A combination of isothermal water overlying water with a negative gradient produces a layer effect. The sound rays from a near-surface source split at the point where the temperature begins to decrease (layer depth). Part of the ray is refracted back toward the surface, whereas the other part is refracted strongly downward. At the point where the rays split, a shadow zone is formed into which very little sound energy penetrates and in which a target may escape detection.

5. Sound channel. A negative gradient in the surface layer overlying an isothermal or positive gradient produces a sound channel. This channel is rare and transitory in the surface layer of the open sea since the thermal conditions causing it are unstable. However, it is quite common at depths where it is termed the "deep, or permanent," sound channel.

What usually occurs in practice is a combination of the various situations (e.g., positive over negative, negative over isovelocity gradients, etc.). However, by keeping in mind that at any point the ray will be bending toward minimum velocity gradients, even the more complex situations are simplified.

Theoretically, the essential difference between shallow and deep water sound transmission is the interference effects produced by multiple reflected transmission paths. Because of these effects, underwater sound problems are divided into two principal categories:

1. Shallow water (water less than 100 fathoms; i.e., water over the Continental Shelf).

2. Deep water (water with a depth greater than 1,000 fathoms).

The area between 100 fathoms and 1,000 fathoms (i.e., the continental slope) is only a small portion of the oceanic area.

Shallow Water Transmission

The interference effects in shallow water transmission are dependent on several environmental factors, the most important being (1) water depth, (2) physical characteristics of the sea surface and bottom, and (3) sound velocity structure.

If we consider the present operational depths of conventional submarines and the sound frequencies in use, then shallow water can be defined as water over the Continental Shelf where depths seldom exceed 100 fathoms. Water depth determines to some extent the types of transmission paths that occur and the range and angle of incidence at which sound rays strike the bottom.

Shallow water bottom composition and its associated degree of roughness control, to a large extent, the reflective capabilities of the bottom, and thus the attenuation of sound. Also, these factors govern the degree of reverberation that contributes to the masking of target echoes. In contrast to deep-sea sediments, which are mostly mud or ooze, the sediments on the Continental Shelf are of diverse types which vary considerably in their composition. Areas of mud, mud-sand, sand, gravel, rock, or coral are not uncommon over shelf regions.

Because of the bottom complexity of sediment distribution, let us consider three aspects of sound transmission through the sea medium and the bottom.

First, the upper portion of the bottom material may be similar in velocity characteristics to the adjacent bottom waters. However, with increasing pressure due to depth, the sediments are compacted and their density increased. This causes the sound velocities to exceed the velocity in water adjacent to the bottom. The net effect is to extend the depth of the sound conducting layer.

Second, in many places the bottom is composed of layers of different acoustic properties. Such layers can channel the transmitted sound signals. In this manner the signal may be transmitted through the bottom over fairly long ranges, even through shallow waters.

Third, the physical and thus the acoustic properties of the bottom materials are changing along the transmission path, and these changes may have an effect on sound transmission.

As an example of how similar sound velocity structures affect shallow and deepwater transmission, consider the following:

In deep water, where strong negative gradients exist, downward refraction results in shadow zones. In this situation a target would be detected only at close range. In shallow water, however, the refracted sound strikes the bottom and is repeatedly reflected, so that the shadow zone becomes isonified (completely blanketed with sound rays by these overlapping reflected paths). Consequently, longer detection ranges are possible (fig. 16-7).

Now let us consider a shallow water medium where the following conditions exist: A perfectly smooth ocean surface and bottom, the sound velocity of the bottom material exceeds that of the adjacent water, the water has isovelocity strucutre, the sound source and receiver are near the surface, and the sound source produces only a single frequency.

This means that all ray paths are straight lines, and their direction changes when they strike the bottom or surface. Further, they leave the reflecting surface at an angle equal to the incident angle. Then, the evaluation of sound intensity becomes a matter of considering the interference effects between multiple reflected rays and direct rays.

Deepwater Transmission

In deep water, sound may travel from source to receiver by surface ducts, sound channel, convergence zone, and bottom bounce. Figure 16-8 shows examples of deepwater transmission paths.

SURFACE DUCTS.—A surface duct (fig. 16-8 (A)) exists in the ocean if the following conditions are met:

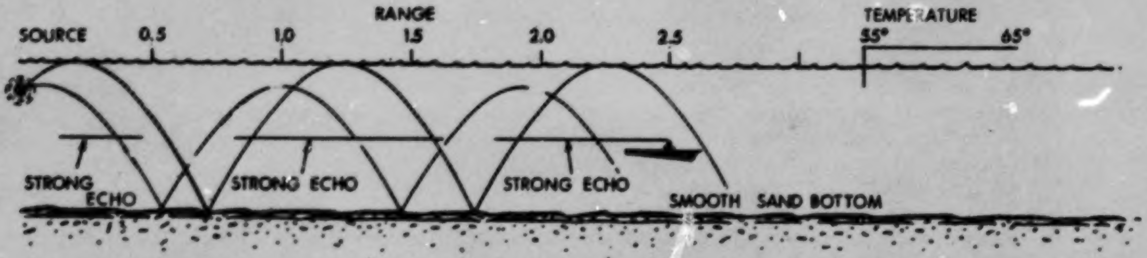
1. The temperature increases with depth.
2. An isothermal layer is near the surface.

In condition 1, sound velocity increases as temperature increases; in condition 2 there is no temperature or salinity gradient, and pressure causes sound velocity to increase with depth. The greater the depth of the duct, the greater is the difference between surface velocity and the velocity at depth, and the greater are the number of rays entrapped. The efficiency of the surface duct in transporting sound also is dependent upon the smoothness of the sea surface.

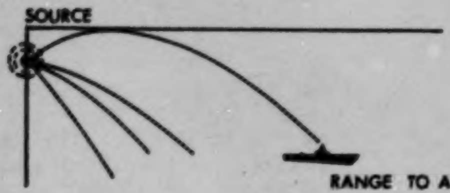
Variations in temperature and the resultant variations in velocity are of utmost importance where the surface duct is utilized, since a change in temperature of 0.4° F per 100 feet makes the difference between an excellent duct and no duct. Horizontal velocity variations may seem negligible, but they can bring about complete deterioration of the duct if the variations occur between the sound source and the target.

SOUND CHANNELS.—In the deep ocean, temperature generally decreases with depth to a little above 0° C at approximately 700 fathoms in the Atlantic Ocean and to about 5° C near 500 fathoms in the Pacific Ocean. The velocity of sound is dependent mainly on temperature and decreases to a minimum at the depth cited; but deeper than 500 to 700 fathoms, velocity increases as a result of pressure.

The zone between these points of similar velocity constitutes a sound channel as illustrated in figure 16-8 (B). The depth at which sound velocity is at a minimum is called the axis of the sound channel. If an omnidirectional sound source and receiver are placed at the axis of the sound channel, a cone of rays is produced at angles above and below the axis. Those rays which start at angles above the



RANGE TO A SUBMARINE IN SHALLOW WATER.
ECHO IS DISCERNIBLE FROM BOTTOM REVERBERATION.



RANGE TO A SUBMARINE IN DEEP WATER

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Figure 16-7.—Range to a periscope-depth submarine in shallow and deep water.

axis are bent down by refraction; those starting at angles below the axis are bent upward. The procedure for locating this axis through analysis is presented later in this chapter.

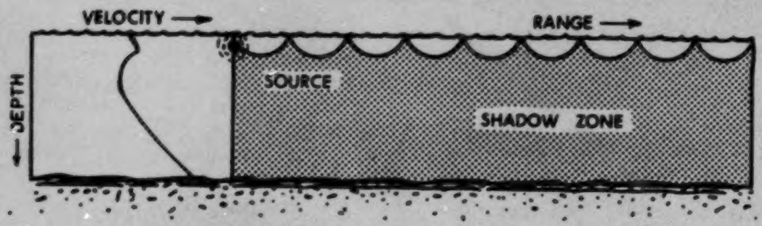
CONVERGENCE ZONE.—This transmission path, illustrated in figure 16-8 (C) is based on the principle that sound energy from a shallow source travels downward in the deep ocean and is refracted at depth toward the surface so that about 30 miles from the source the sound signal again reaches the surface. From there the signals continue as they are reflected downward and then refracted upward to reappear in the surface layer at successive intervals of about 30 miles out to several hundred miles.

The conditions for convergence zone transmission require that the sound velocity at depth be equal to or greater than the velocity at the surface and that water depth below this second velocity maximum be sufficient for a bundle of sound rays to be refracted so that they converge at the surface in a small area.

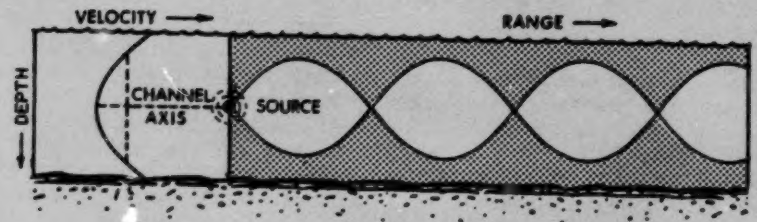
BOTTOM BOUNCE.—The three transmission paths already discussed depend upon the restrictive conditions of the velocity structure and the depth of the sound source and receiver. Thus, if velocity gradients are ignored, prediction of the paths is not possible. The fourth path can be predicted roughly even if these gradients are neglected. This path is the bottom reflected path, commonly termed bottom bounce. (See fig. 16-8 (D).)

Bottom bounce is in part successful because the angle of the ray path is such that the sound energy is affected to a lesser degree by velocity changes than the more nearly horizontal ray paths of other transmission modes.

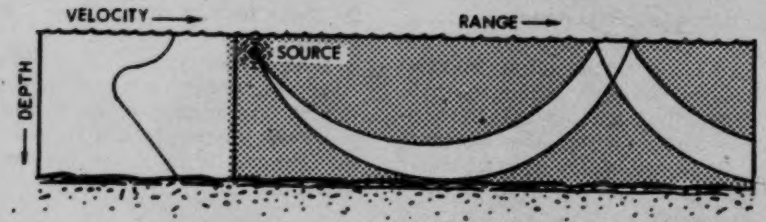
Long range paths can occur with water depths greater than 1,000 fathoms, depending on bottom slope; but at shallower depths, multiple bounce paths develop which produce high intensity loss. It is estimated that 85 percent of the ocean is deeper than 1,000 fathoms, and bottom slopes are generally less than or equal to 1 degree. On this basis, relatively steep angles can be used for single bottom reflection to ranges of approximately 20,000 yards. With steeply inclined rays, transmission is relatively free from thermal effects


VELOCITY →
RANGE →
DEPTH
SOURCE
SHADOW ZONE

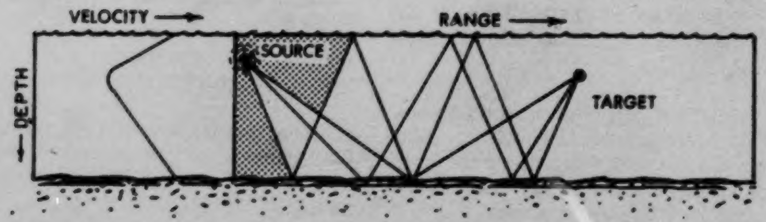
(A) SURFACE DUCT


VELOCITY →
RANGE →
DEPTH
CHANNEL AXIS
SOURCE

(B) DEEP SOUND CHANNEL


VELOCITY →
RANGE →
DEPTH
SOURCE

(C) CONVERGENCE ZONE


VELOCITY →
RANGE →
DEPTH
SOURCE
TARGET

(D) BOTTOM BOUNCE

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Figure 16-8.—Sound transmission paths. (A) Surface duct; (B) deep sound channel; (C) convergence zone; (D) bottom bounce.

at the surface and the major part of the sound path is in nearly stable water.

MAJOR CURRENT SYSTEMS

Ocean currents transport vast quantities of water with differing characteristics from one region of the earth to another. Since three-fourths of the earth's surface is composed of water, it is not difficult to understand why the Aerographer's Mate must become familiar with ocean current systems and the effects they have on certain regions.

Ocean currents are established and maintained primarily by the stresses exerted by the prevailing winds over the surface of the sea. Moving water obeys the same laws of deflection as moving air. It is deflected to the right in the Northern Hemisphere and toward the left in the Southern Hemisphere. The earth's rotation provides the basic cause for this pattern of deflection. The prevailing winds along the ocean surface also determine some of the circulation characteristics. Thus, an oceanic circulation that roughly corresponds to the atmospheric circulation is maintained.

The orientation of coastlines often modifies this circulation. Since the air circulation over the oceans in middle latitudes is chiefly anticyclonic (more pronounced in the Southern Hemisphere than in the Northern Hemisphere), we can expect the oceanic circulation at these latitudes to be the same. At higher latitudes, where the flow is principally cyclonic, the oceanic circulation follows this cyclonic pattern, although not as closely as the anticyclonic pattern of the lower latitudes. In regions with a pronounced monsoonal flow, the ocean currents respond to this flow. The following statements can be made concerning general distribution of ocean currents.

At middle (below 40° lat) and low latitudes, continents have warm currents which flow poleward along their east coasts and cold currents flowing equatorward along their west coasts. This is true in both hemispheres.

In the Northern Hemisphere at high latitudes, continents have cold currents flowing equatorward along their east coasts and warm currents flowing poleward along their west coasts. In monsoonal regions, ocean currents vary with the seasons. The presence of an irregular coastline will cause deviation in the general distribution of ocean currents.

The circulation of ocean waters acts to transport heat from one latitude belt to another in a manner similar to the heat transported by the primary circulation of the atmosphere. The cold waters of the Arctic regions move to warmer sections of the earth, while the warm waters of the low latitudes move toward the poles.

An example of this effect on climate is shown by the comparatively mild climate that exists in the area of northwest Europe. The coast of Norway, as far north as it is, is mild enough that its ports on the Atlantic are ice-free for the most part during the long winter. This is due to the effect of the ocean current which sweeps the Atlantic Ocean from the equatorial regions. The cold ocean current off the coast of California is a decisive factor in giving cities such as San Francisco such cool temperature readings in summer.

Meteorologists are normally more interested in the effect of the surface temperature of the ocean's water than in the manner in which the waters have arrived at a particular locality. Even so, ocean currents and their relationship to the prevailing winds of the weather picture must be understood. Figure 16-9 shows the surface currents of the oceans during February and March.

NORTH ATLANTIC CURRENTS

Movements of the waters of the North Atlantic Ocean are dominated by the NORTH EQUATORIAL CURRENT and the GULF STREAM SYSTEM.

North Equatorial Current

The North Equatorial Current is located in the trade wind belt of the North Atlantic Ocean. The chief sources of the flow are the northeasterly currents off the west coast of northwestern Africa. These currents of water of relatively high density and low temperatures are from the North Atlantic Current, and they help to cause the temperatures of the northwest coast of Africa to be lower than normally would

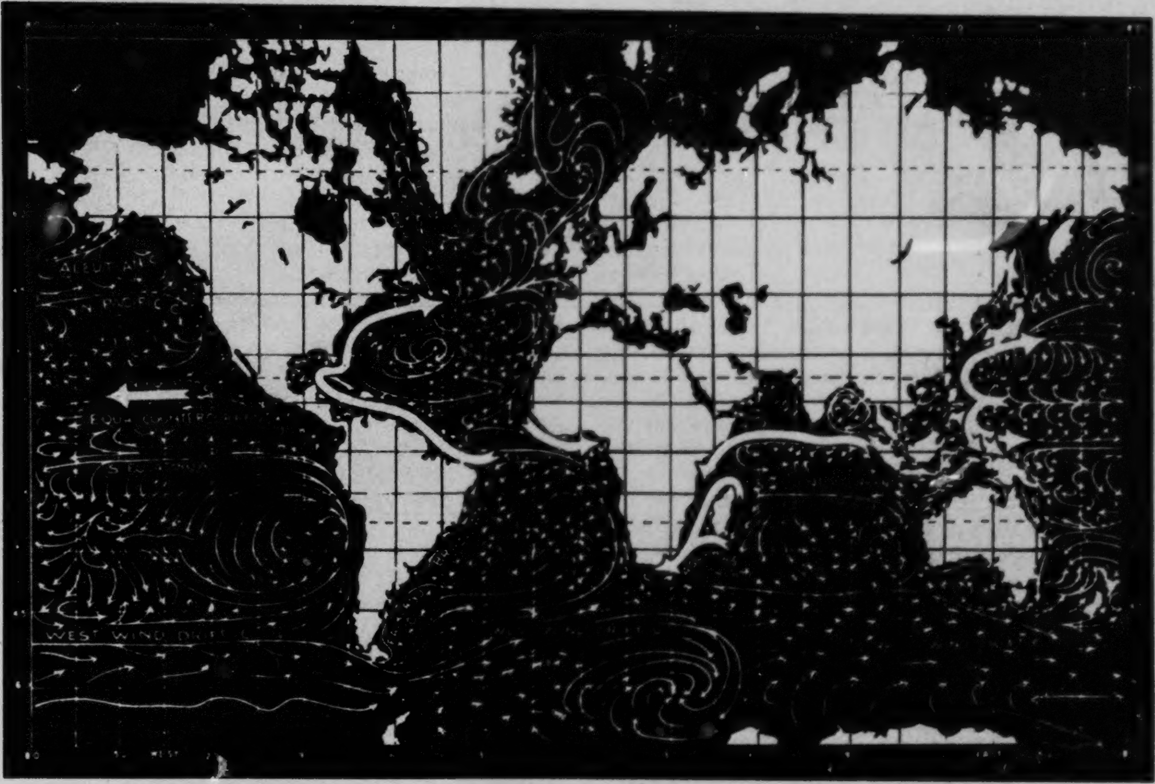

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Figure 16-9.—Surface currents of the oceans (February-March).

be expected. The temperatures near the coast are further lowered by the UPWELLING of colder water from moderate depths; the upwelling is caused by the prevailing winds. The upwelling here is not as pronounced as at some other localities. Upwelling of ocean water is the process by which the colder subsurface waters are brought to the top. This is made possible in areas where the winds cause the surface water to be transported away from the coast, with the surface water being replaced by the colder subsurface water. In the Northern Hemisphere upwelling is common where a wind blows parallel to the coast, with the coast on the left side of the wind, which causes the surface water to be transported to the right and away from the coast. In the process of upwelling, the overturn of water takes place only in the upper layers (to a maximum depth of about 150 fathoms).

A branch of the SOUTH EQUATORIAL CURRENT crosses the Equator from the South Atlantic Ocean and joins with the North Equatorial Current in the western part of the North Atlantic Ocean. Consequently, the part of the North Equatorial Current that enters the Caribbean Sea has water that has been mixed with water of the South Atlantic Ocean. The northern branch of the North Equatorial Current which flows along the northern side of the Greater Antilles is called the ANTILLES CURRENT. It carries water that is virtually the same as that of the Sargasso Sea (a portion of the middle North Atlantic Ocean).

Gulf Stream System

The northward and eastward flow of water that begins in the Florida Straits is known as the Gulf Stream system. These waters include all of the various branches of the western North Atlantic Ocean that can be traced to the region south of the Grand Banks off Newfoundland. They are the FLORIDA CURRENT, GULF STREAM, and NORTH ATLANTIC CURRENT.

The FLORIDA CURRENT consists of the northward moving water from the Florida Straits to the vicinity of the coast of Cape Hatteras. Much of the flow is derived from the Caribbean Sea by way of the Yucatan Channel; the water from the Yucatan Channel takes the shortest route to the Florida Straits rather than making a long sweep through the Gulf of Mexico. The Florida Current is also fed by the Antilles Current. The energy of the Florida Current is believed to come from the difference in the levels of the water in the Gulf of Mexico and the water adjacent to the Florida Atlantic coast. The difference in the two levels is due to the prevailing trade winds which result in a piling up of water in the gulf.

The GULF STREAM is considered to be the middle portion of the Gulf Stream system, beginning near Cape Hatteras, where the current leaves the continental slope. It continues northward to the vicinity of the Grand Banks off Newfoundland, flowing for a considerable distance off the continental shelf. To the right of the Gulf Stream is the Sargasso Sea portion of the North Atlantic Ocean; to the left are the coastal and slope waters.

The NORTH ATLANTIC CURRENT begins off the Grand Banks, where the Gulf Stream begins to fork. It consists of northerly and easterly currents terminating in subsidiary currents. One of the major subsidiaries is the IRMINGER CURRENT, which flows westward off the southern coast of Iceland. Another is the NORWEGIAN CURRENT. It flows beyond the Norwegian Sea into the Polar Seas. Other branches of the North Atlantic Current, turning southward, end in huge eddies off the coast of Europe and in the relatively cold CANARIES CURRENT off the northwest coast of Africa.

NORTH PACIFIC CURRENTS

The currents of the North Pacific Ocean are very similar to the currents of the North Atlantic Ocean. Even so, there are some distinct differences. These are due mainly to the large amounts of subarctic water in the North Pacific compared to the small amount in the North Atlantic.

North Equatorial Current

The origin of the North Equatorial Current of the North Pacific Ocean is in the vicinity of the western coast of Central America where waters of the EQUATORIAL COUNTERCURRENT turn northward. As the North Equatorial Current makes its way across the Pacific from the east to the west, other waters are added, including the CALIFORNIA CURRENT and waters of the eastern North Pacific and of the western North Pacific. Toward the western side of the North Pacific most of the waters turn northward along the eastern coast of the northern Philippines and Formosa; some of the waters turn southward and become a part of the Equatorial Countercurrent. Consequently, the North Equatorial Current takes very warm water to the eastern side of the island systems in the western North Pacific.

Cromwell Current

The Cromwell is a narrow, swift current centered on the Equator, extending from 2°N to 2°S. Its longitudinal dimensions are from 140°W to 92°W. At the Equator the easterly flow appears at approximately 20 meters, reaching a maximum speed of 2 to 2.5 knots at 100 meters, and disappears at roughly 250 meters.

Kuroshio System

The Kuroshio system is quite similar to the Gulf Stream system of the North Atlantic Ocean. It has its origin in the North Equatorial Current of the North Pacific Ocean, and it is situated in the extreme western portion of the ocean. It flows past Formosa and northeastward in the deep ocean area between the China Sea and the Ryukyu Islands. The system flows eastward and northeastward along the coast of Japan.

Divided into three branches, the Kuroshio system consists of the KUROSHIO, the KUROSHIO EXTENSION, and the NORTH PACIFIC CURRENT.

The KUROSHIO corresponds to the Florida Current of the Gulf Stream system. It is the portion of the Kuroshio system that flows from Formosa to about 35°N lat. The salinity of the Kuroshio Current is less than that of the Florida Current. Cold offshore winds have a marked cooling effect on the Kuroshio, causing an annual range in temperature of as much as 9° C in some localities.

The KUROSHIO EXTENSION is the continuation of the warm Kuroshio Current. It divides into two branches at 35°N lat. The major portion flows eastward as a well-defined current to about 160°E long. The other portion flows northeastward to about 40°N lat., where it turns eastward.

The NORTH PACIFIC CURRENT is a prolongation of the Kuroshio Extension. Since the current is not well defined, it is difficult to trace its progress across the Pacific Ocean. It seems that it definitely extends from about 160°E long. to about 150°W long. Much of the waters turn southward before reaching 150°W long. and form many of the major whirls that are rather pronounced in that portion of the North Pacific. Temperature and salinity are the two best clues as to the location of the current. It is believed that some of the waters extend east of the Hawaiian Islands before turning south between the island chain and western North America.

SOUTH ATLANTIC CURRENTS

The prevailing anticyclonic wind circulation of the Southern Hemisphere gives to the South Atlantic Ocean its characteristic oceanic circulation.

The SOUTH EQUATORIAL CURRENT dominates the northern portion of the South Atlantic. It flows from east to west just south of the EQUATORIAL COUNTERCURRENT. On reaching the eastern shores of South America, one branch turns northward along the northern coast of South America, merging with the waters of the North Equatorial Current to become a part of the Gulf Stream system of the North Atlantic; the other branch flows southward as the BRAZILIAN CURRENT, brining waters of high temperature and high salinity to the coasts of Brazil and Uruguay.

One branch of the West Wind Drift Current turns northward along the coast of Argentina and is known as the FALKLAND CURRENT. It brings to that area waters of low temperature and low salinity. Where the Falkland Current and the Brazilian Current meet at about 40° south latitude, the two currents turn eastward, developing great whirls in the middle section of the South Atlantic.

On the African side of the South Atlantic Ocean, there is one dominant current. It is the BENGUELA CURRENT. The Benguela Current is another northward flow of waters from the West Wind Drift Current. It brings low clouds and fog along the immediage southwestern coast. In the region of the Equator the Equatorial Countercurrent flows eastward to the coast as the GUINEA CURRENT, favoring warm, moist air and heavy rainfall.

SOUTH PACIFIC CURRENTS

The currents of the South Pacific Ocean show the effects of the anticyclonic circulation of the atmosphere. The northern portion of the South Pacific is dominated by the SOUTH EQUATORIAL CURRENT which flows from east to west just south of the EQUATORIAL COUNTERCURRENT. On reaching the western end of the ocean the South Equatorial Current turns southward as the EAST AUSTRALIA CURRENT and bathes the northern and eastern shores of Australia with warm waters. Turning eastward as it flows past the eastern coast of Australia, it brings warm waters to the northern and western coasts of New Zealand. As a result, the eastern coast of Australia and the western coast of New Zealand are warmer than the opposite coasts.

The southern portion of the South Pacific is dominated by the WEST WIND DRIFT CURRENT. This current completely encircles the Southern Hemisphere and has a marked effect on the equatorward-moving currents.

The PERU CURRENT, which is a branch of the West Wind Drift Current, dominates the coastal waters of western South America. The waters are relatively cold. There is considerable upwelling of the cold subsurface waters off the coasts of Chile and Peru due to the prevailing southerly winds. Coastal fogs and low clouds are characteristic of the area.

SEAS ADJACENT TO THE NORTH ATLANTIC

There are several currents of seas adjacent to the North Atlantic Ocean that must be mentioned in order to complete the picture of oceanic circulation in that region.

Mediterranean Sea

There is a strong current in the Strait of Gilbraltar, where the waters of the North

Atlantic Ocean flow into the Mediterranean Sea in the upper layers of the current and the waters of the sea flow into the ocean in the lower layers. The outflowing waters of the Mediterranean Sea have lower temperatures and greater salinity than the inflowing waters of the North Atlantic.

Labrador Sea and Baffin Bay

Waters from the North Atlantic Ocean enter the Labrador Sea along the west coast of Greenland as the WEST GREENLAND CURRENT. Some of the West Greenland Current continues through Davis Strait into Baffin Bay; the remainder turns westward and joins the LABRADOR CURRENT, which flows southward along the east coast of Labrador.

Some of the cold water from this current turns eastward and flows along the northern border of the North Atlantic Drift, and some flows southward along the east coast of North America, inshore of the Gulf Stream as far as Cape Hatteras.

Caribbean Sea and Gulf of Mexico

The strong current that exists in the Caribbean Sea is a continuation of the southern branch of the North Equatorial Current of the Atlantic Ocean. The waters flow westward through the Caribbean Sea with two conspicuous eddies accompanying the main current. One of the eddies is in the bay between Nicaragua and Colombia; the other is between Cuba and Jamaica. The main current continues through the YUCATAN CHANNEL between the Yucatan Peninsula of Mexico and Cuba. Most of the waters of the current bend sharply to the east and join the Florida Current through the Florida Straits. Some flows into the Gulf of Mexico, where most of the circulation is in the form of pronounced eddies, which are due to the contours of the coast and the character of the gulf floor.

OTHER NORTH PACIFIC CURRENTS

To complete the picture of the oceanic circulation in the North Pacific Ocean, several other currents of adjacent seas must be mentioned.

Aleutian Current

To the north of the North Pacific Current is a current of waters flowing also toward the east. This current is known as the Aleutian Current. One branch of the Aleutian Current flows north of the Aleutian Islands and continues around the Bering Sea in a counterclockwise circulation, and joins with water flowing southward through the Bering Strait. This water then flows southward to the northern islands of Japan as the OYASHIO CURRENT. The oyashio divides at 40°N lat; one branch becomes a part of the Kuroshio, and the other branch moves south along the coast. In the winter the Oyashio carries cold waters as far south as Vietnam. In the summer the cold water circulation is kept to the area north of 40°N lat by the summer monsoon circulation.

The other branch of the Aleutian Current flows south of the Aleutian Islands. On approaching the coast of North America, one portion turns to the north and flows into the Gulf of Alaska; the other portion turns south and flows along the coast as the CALIFORNIA CURRENT.

California Current

The portion of the Aleutian Current that flows into the Gulf of Alaska is considered a warm current, since it brings milder winter temperatures to southern Alaska than would normally be expected at that latitude. On the other hand, the California Current in the spring and summer definitely has a cooling effect on the western coast of the United States. Due to the north-northwest winds during those seasons there is a great deal of upwelling of the subsurface cold waters. In the fall the upwelling gives way and a countercurrent in the surface waters known as the DAVIDSON CURRENT flows northward along the coast to about 48°N lat.

Where the upwelling is intense the spring temperatures are lower than the winter temperatures. However, in areas of only moderate upwelling the winter temperatures are lower. Associated with areas of much upwelling are tongues of water of low temperature that extend in a southerly direction away from the coast. These tongues are separated by tongues of water with a higher temperature that protrude toward the coast. The tongues of water with lower temperature flow toward the south; the tongues of water with higher temperature flow toward the north.

INDIAN OCEAN CURRENTS

The oceanic circulation of the Indian Ocean shows the influence of the Asiatic Monsoon atmosphere circulation in the northern portion of the ocean and the anticyclonic circulation in the southern portion.

The equatorial currents of the North Indian Ocean are variable. During the northwest monsoon (February and March) the wind aids the north equatorial current, causing it to be well developed in its circulation from east to west. Immediately to the south of the North Equatorial Current during that season there is a pronounced countercurrent. In August and September during the southwest monsoon, the North Equatorial Current flows from west to east as the MONSOON CURRENT, and the EQUATORIAL COUNTERCURRENT seems to disappear.

A large portion of the equatorial currents reaching the east coast of Africa turns southward. South of the Equator this branch is known as the MOZAMBIQUE CURRENT to about 35°S lat, where it becomes known as the AGULHAS STREAM. These waters are favorable to warm, moist air masses with moderate rainfall along the southeast coast of Africa.

Some of the equatorial waters make their way to the West Wind Drift Current in the South Indian Ocean and flow eastward toward Australia. On reaching the vicinity of the west coast of Australia, some of the waters of the West Wind Drift flow northward bringing to that area relatively cool sea surface temperatures and the formation of fog and low stratus clouds.

SUMMARY

In general, the following statements may be made concerning the effects ocean currents have on weather:

1. West Coasts of Continents in Tropical and Subtropical Latitudes (except close to the Equator) are bordered by cool waters, and their average temperatures are relatively low with small diurnal and annual ranges. There are fogs, but generally the areas are arid (southern California, Morocco, etc.).

2. West Coasts of Continents in Middle and Higher Latitudes are bordered by warm waters which cause a distinct marine climate. They are characterized by cool summers and relatively mild winters with small annual range of temperatures (upper west coasts of the United States and Europe).

3. East Coasts in the Tropics and Subtropical Latitudes are paralleled by warm currents and have resultant warm and rainy climates. These areas lie in the western margins of the subtropical anticyclones and are relatively unstable (Florida, Philippines, Southeast Asia).

4. East Coasts in the Lower Middle Latitudes (leeward side) have adjacent warm waters with a modified continental-type climate. The winters are fairly cold, and the summers are warm and hot.

5. East Coasts in the Higher Middle Latitudes. Cool ocean currents parallel the coasts with subsequent cool summers.

The indirect effects of ocean currents have their influence upon the location of the primary frontal zones and the tracks of cyclonic storms. Off the eastern coast of the United States in the winter two of the major frontal zones are located in areas where the temperature gradient is steep and where a large amount of tropical water is being transported into the middle latitudes. In contrast to the cold eastern side of the continent, marked thermal temperature contrasts occur. The fact that these frontal zones are positioned in a location where large amounts of energy are available suggests that cyclones developing in these regions along the primary front may be of thermodynamic origin. Two of the main hurricane tracks in the Atlantic also appear to follow warm waters, one through the Caribbean and the other following the warm waters off the northern and eastern coasts of Florida and the Greater Antilles. Extratropical cyclones, too, tend to be attracted to warm waters in fall and early winter. This is equally true in the United States and in European waters.

WATER MASSES AND TYPES

Chapter 14 of this training manual discussed the concept of visualizing various bodies of air with similar characteristics and distinguishing between them in terms of "air masses." The same concept may be applied to bodies of water with similar characteristics. However, in the ocean there exists a more steady state of the environment than that found in the atmosphere. Therefore, water masses are found to remain within more well-defined areas than air masses are.

In middle and low latitudes the arrangement of water masses vertically is such that one can distinguish between the surface layer, the upper water, the intermediate water, the deep water and in some localities, the bottom water. In high latitudes, the intermediate water is often lacking, and the upper water is similar to the deep water.

FORMATION

The density of water increases with depth. However, in a horizontal direction, the density generally increases toward the polar regions. Surface water of a given density which is sinking in higher or middle latitudes will sink until it reaches a level of constant density and then begin to spread out horizontally. As a result, in middle latitudes, the vertical and horizontal distribution of density will be nearly the same during those seasons when surface waters are most frequently subsiding. Water masses may generally be said to form either through the process of sinking surface waters or by subsurface mixing.

The vast majority of water masses are formed at the surface of the sea. They then sink and spread outward from their source regions in a manner that depends on their density in relation to the density of the surrounding oceans. This is true of nearly all water masses with the exception of the equatorial water masses of the Indian and the Pacific Oceans, which are formed by the process of subsurface mixing. Water masses do not normally form at the surface in low latitudes.

DISTRIBUTION

Central Water Masses

Figure 16-10 is provided as a reference for the source regions of the various water masses discussed in the following paragraphs.

The Central Water masses are normally found in relatively low latitudes although their source region is in the region of the subtropical convergences (between 35° and 40° North and South of the equator).

The Central Water masses of the South Atlantic, the Indian Ocean, and the western South Pacific Ocean have similar properties since in the regions where they are formed, circulation, heating, and cooling processes are also similar. The water masses of the eastern South Pacific have lower salinity than those found in the western portion, probably because of the mixing of the low salinity Subantarctic Water with that of the Peru Current. Similar mixing processes also contribute to the Central Waters of the western South Pacific which in a like manner have slightly lower salinity than the Central Water of the Indian and South Atlantic Oceans.

The Central Waters of the North Atlantic and the North Pacific Oceans vary considerably, primarily due to the high salinity content of the North Atlantic as compared to the relatively low salinity of the North Pacific. These differences are probably due to variations in the ocean circulation, amounts of precipitation, and evaporation as a result of land and sea distribution, especially in the higher latitudes.

The vertical extent of the Central Water masses are generally relatively shallow, with the greatest thicknesses being observed along their western boundaries. They may reach 900 meters in the Sargasso Sea region of the North Atlantic.

The opposing Central Water masses in the equatorial parts of the North and South Atlantic Ocean are separated by a transitional region which consists of intermediate properties as a result of mixing between the two regions. However, in the Pacific Ocean the separation between the Central Water masses is well defined since they are separated by another water mass referred to as Equatorial Water.

Equatorial Water Masses

Equatorial Water probably forms on the Southern side of the Equator in the Pacific since it is similar to the water mass of that ocean and has a higher salinity than any of the water masses of the North Pacific Ocean.

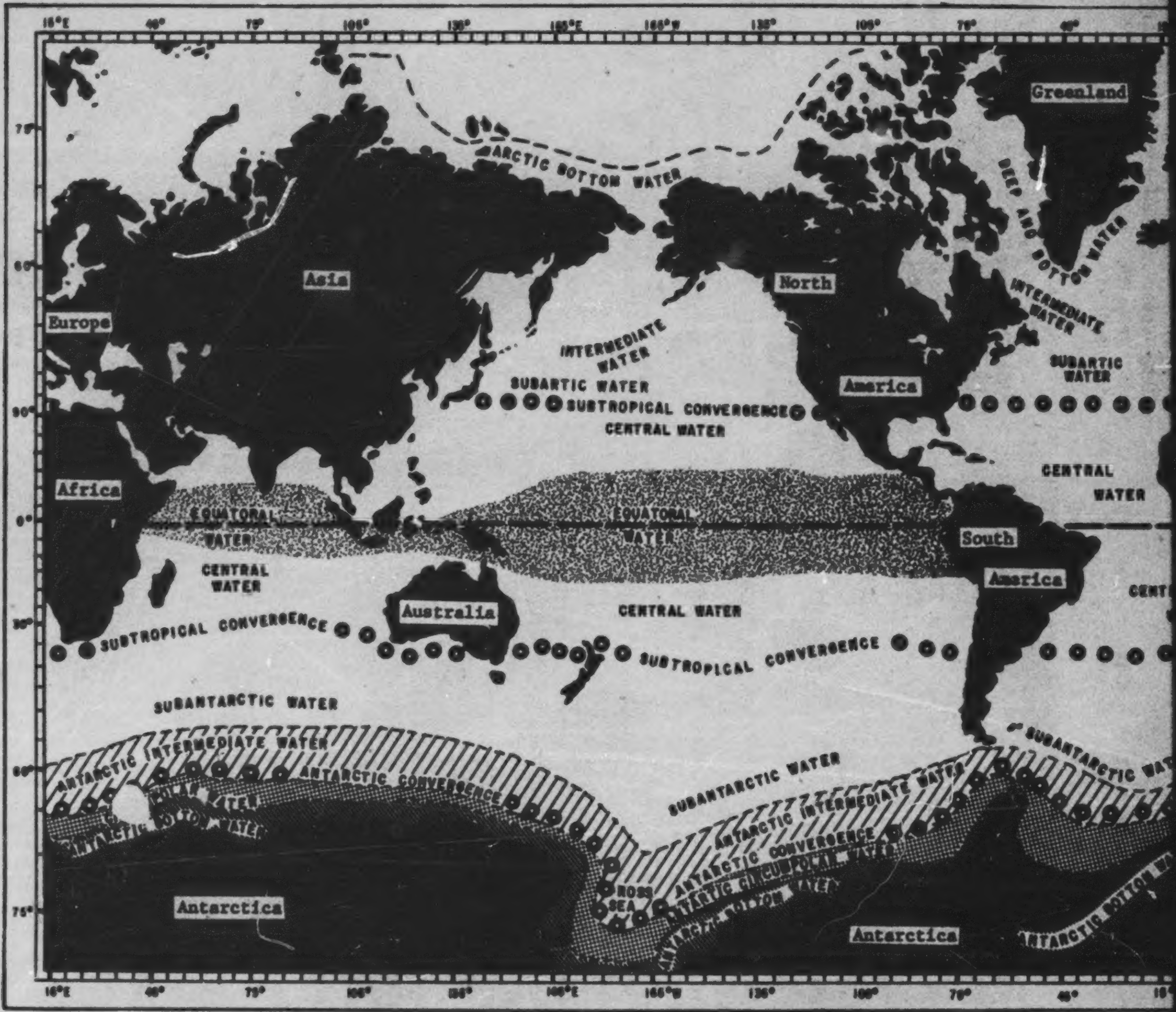
15°E
45°
75°
105°
135°
165°E
165°W
135°
105°
75°
45°
75°
60°
30°
0°
30°
60°
75°
Greenland
ARCTIC BOTTOM WATER
DEEP AND BOTTOM WATER
INTERMEDIATE WATER
Asia
Europe
North
America
INTERMEDIATE WATER
SUBARTIC WATER
SUBARTIC WATER
SUBTROPICAL CONVERGENCE
CENTRAL WATER
CENTRAL WATER
Africa
EQUATORIAL WATER
EQUATORIAL WATER
South
America
CENTRAL WATER
Australia
CENTRAL WATER
SUBTROPICAL CONVERGENCE
SUBTROPICAL CONVERGENCE
SUBANTARCTIC WATER
ANTARCTIC INTERMEDIATE WATER
ANTARCTIC CONVERGENCE
CIRCUMPOLAR WATER
ANTARCTIC BOTTOM WATER
SUBANTARCTIC WATER
SUBANTARCTIC WATER
ANTARCTIC INTERMEDIATE WATER
ANTARCTIC CONVERGENCE
ANTARCTIC CIRCUMPOLAR WATER
ANTARCTIC BOTTOM WATER
ROSS SEA
Antarctica
Antarctica
ANTARCTIC BOTTOM WATER

Figure 16-10.—Approximate source regions for water masses of the world.

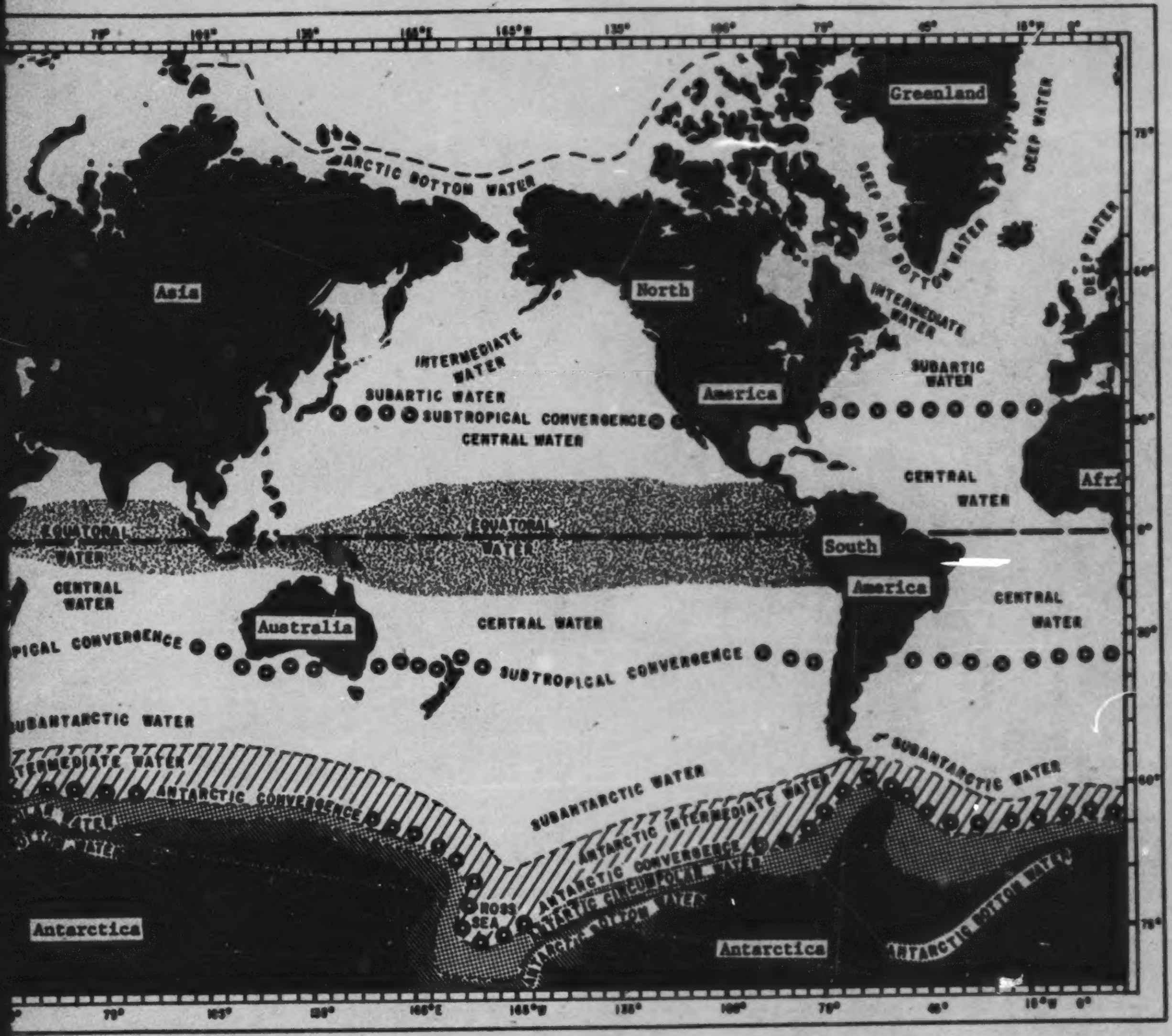
Asia
North
America
South
America
Greenland
Australia
Antarctica
Antarctica
Afri
ARCTIC BOTTOM WATER
DEEP WATER
DEEP AND BOTTOM WATER
DEEP WATER
INTERMEDIATE WATER
INTERMEDIATE WATER
SUBARTIC WATER
SUBARTIC WATER
SUBTROPICAL CONVERGENCE
CENTRAL WATER
CENTRAL WATER
EQUATORIAL WATER
EQUATORIAL WATER
CENTRAL WATER
CENTRAL WATER
CENTRAL WATER
PICAL CONVERGENCE
SUBTROPICAL CONVERGENCE
SUBANTARCTIC WATER
SUBANTARCTIC WATER
SUBANTARCTIC WATER
TERMEDIATE WATER
ANTARCTIC CONVERGENCE
ANTARCTIC INTERMEDIATE WATER
ANTARCTIC CONVERGENCE
ANTARCTIC CIRCUMPOLAR WATER
ANTARCTIC BOTTOM WATER
ANTARCTIC BOTTOM WATER
ROSS SEA
75°
60°
30°
0°
30°
60°
75°
75°
105°
135°
165°E
165°W
135°
105°
75°
45°
15°W
0°

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Figure 16-10.—Approximate source regions for water masses of the world.

The Equatorial Water mass is also found in the northern part of the Indian Ocean. In this case, the higher salinities of Equatorial Water are probably due to mixing with Red Sea water; however, this conclusion has not been definitely established.

The Central and Equatorial Water masses are usually not discernible at the surface, but are covered by a surface layer of 100 to 200 meters in thickness. In this surface layer, the temperature and salinity of the water indicate wide variations from one area to another, depending on variations in current structure, evaporation, precipitation, and various seasonal changes, especially in the middle latitudes. This surface layer of warm water is separated from deeper water by a transition layer within which the temperature decreases rapidly with depth.

Subantarctic and Subarctic Water Masses

Subantarctic Water occurs between the Central Water masses of the southern oceans and the Antarctic Convergence. The physical properties of this water mass are quite conservative and extend completely around the earth. Subantarctic Water is considered to belong to the waters of the Antarctic Ocean. This water is of relatively low salinity and is probably formed by a combination of mixing and vertical circulation in the region between the Subtropical and Antarctic Convergences. The corresponding Subarctic Water of the North Atlantic is not nearly as extensive as that of the Subantarctic Water of the South Atlantic. It covers only a small area and is found to have a higher salinity than the surrounding water. However, in the North Pacific the corresponding Subarctic Water covers a wide area and is of lower salinity than the surrounding water.

The variations between the Subarctic Water and the Subantarctic Water masses indicate that they must be formed by different processes. In the southern oceans the Antarctic Convergence presents a continuous and well-defined boundary, whereas in the northern oceans the corresponding Arctic Convergence is found only in the western portions of the oceans. In some areas there exists no well-defined northern boundary to the Subarctic Water. The differences between the water masses of the northern and southern oceans are reflections of the differences in the character of the land and sea distribution. Although Subarctic Water is similar to Arctic Intermediate Water, Subantarctic Water differs distinctly from Antarctic Intermediate Water.

Intermediate Water Masses

Intermediate Water masses are found below Central Water masses in all oceans. The Antarctic Intermediate Water is the most widespread. Intermediate Water differs from Central Water in that it sinks along a well-defined line. It does not form as a WATER MASS at the surface and then sink. Instead, it forms from the sinking of a WATER TYPE (see definitions at the beginning of this chapter) with a salinity of 33.8 ‰ and a temperature of 2.2° C which encircles the Antarctic Continent and mixes with the waters above and below. This mixing gradually develops into a water mass. One of the characteristics of the Intermediate Water mass is a salinity minimum when compared with the surrounding water. Since the Equatorial Water does not exist to form a boundary between the north and south in the Atlantic Ocean, the salinity minimum of the Antarctic Intermediate Water extends across the Equator to about 20° to 35°N latitude. In the South Pacific and Indian Oceans where Equatorial Water exists, the Antarctic Intermediate Water spreads northward to around 10°S latitude.

Arctic Intermediate Water forms in small quantities east of the Grand Banks of Newfoundland in a small area of the northwest Atlantic.

The Arctic Intermediate Water of the North Pacific lies between latitude 20° and 43°N except off the North American west coast where Subarctic Water flows farther southward. Arctic Intermediate Water of the North Pacific is formed during the winter at the convergence formed by the Oyashio Current and the Kuroshio Extension. The Oyashio is a cold, southerly moving current (described earlier in this chapter) that converges with the warm, northeasterly moving waters of the Kuroshio at a latitude of about 40°N and a longitude around 160°E.

There are two other Intermediate Water masses likely to be encountered by the Aerographer's Mate in his studies of Oceanography. These are those formed in the Atlantic and Indian Oceans as a result of the interactions of Mediterranean Water in the Atlantic and Red Sea Water in the Indian Ocean. The

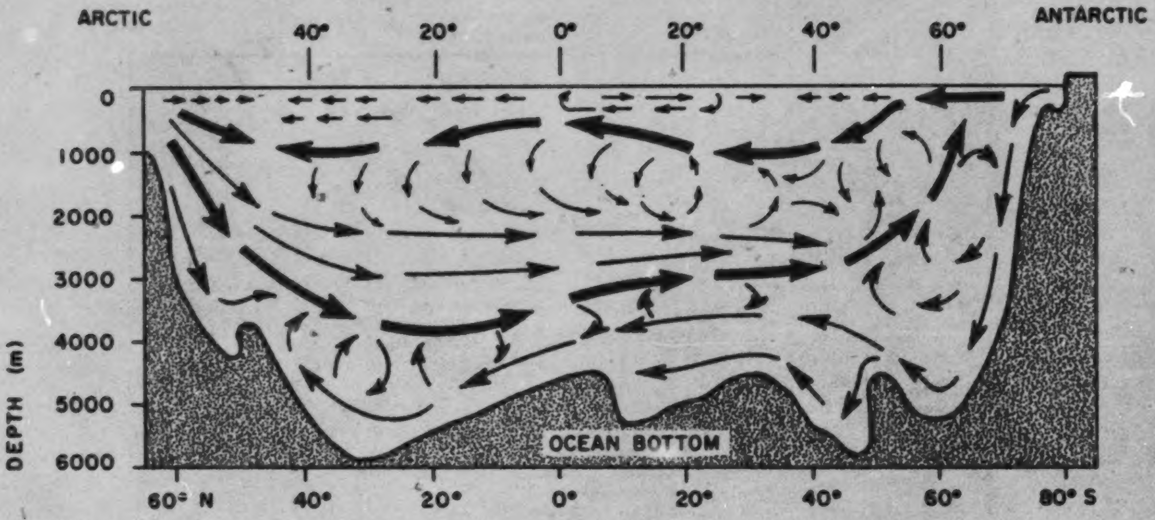

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Figure 16-11.—Simplified general circulation pattern of the Atlantic Ocean.

Mediterranean Water flowing along the bottom of the Strait of Gibraltar mixes with surrounding Atlantic Water and spreads out between surfaces below the Antarctic Intermediate Water. The spreading of the Red Sea Water is not so well defined but may be recognized over large parts of the equatorial and western regions of the Indian Ocean by its higher salinity values.

Deep and Bottom Water Masses

Below the Intermediate Water the deep ocean basins are filled by Deep and Bottom Water of high density. These water masses are formed near the Antarctic Continent and in the high latitudes of the northern oceans. The spreading of these Deep Water masses are detectable in areas outside their source regions all around the world. More information on the spreading of Deep and Bottom Water is presented in the following discussion of oceanic circulation.

CIRCULATION

Figure 16-11 serves to illustrate a number of interesting features regarding circulation of the ocean waters.

Notice that the deep water flows outward along the bottom from the Antarctic Continent. This movement results in the existence of Antarctic Bottom Water, Circumpolar Water, and Antarctic Intermediate Water not only in the Antarctic regions but also throughout the southern portions of the oceans as these high density Deep Water masses move away from their source region. This outward motion of water masses is not only characteristic to the Antarctic region but occurs with Arctic Deep Water, Mediterranean Water, and Red Sea Water as well.

As the Deep Water and Bottom Water formed by sinking and spreading of HIGH DENSITY water in the Subarctic and Subantarctic regions of the Atlantic and Pacific are modified by HIGH SALINITY water flowing out of the Red Sea into the Indian Ocean, a circulation such as that illustrated in figure 16-11 is established in the oceans. The northern oceans' Deep Water and Bottom Water flow away from their sources and are replaced by surface and intermediate waters returning the waters toward their originating areas.

Many secondary circulations are created within this simplified general circulation. For example, the Antarctic Bottom Water which contains relatively low salinity flows northward along the bottom to near 35°N. This influx of low salinity water causes the salinity of the bottom water in the northern oceans to

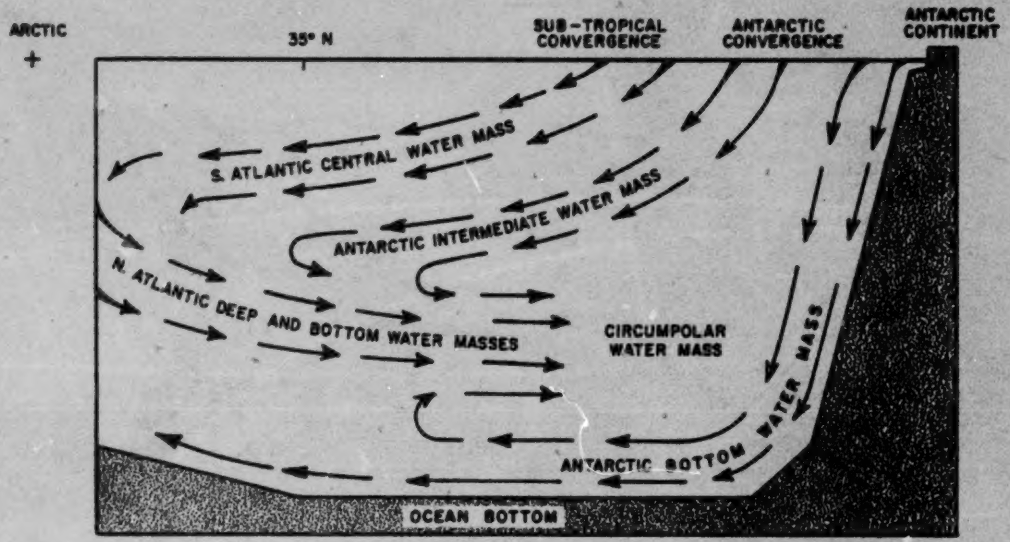
ARCTIC
35° N
SUB-TROPICAL CONVERGENCE
ANTARCTIC CONVERGENCE
ANTARCTIC CONTINENT
S. ATLANTIC CENTRAL WATER MASS
ANTARCTIC INTERMEDIATE WATER MASS
N. ATLANTIC DEEP AND BOTTOM WATER MASSES
CIRCUMPOLAR WATER MASS
ANTARCTIC BOTTOM WATER MASS
OCEAN BOTTOM

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Figure 16-12.—Typical flow pattern of circulation with the southern ocean.

decrease toward the south. North Atlantic Deep Water flowing into the south Atlantic is then sandwiched between Antarctic Bottom Water below and Antarctic Intermediate Water above as illustrated in figure 16-12.

Large quantities of Antarctic Intermediate and Bottom Water mix with the southward flowing Atlantic water and return to Antarctica producing Circumpolar Water. This process also produces a strong upwelling in the area between the sinking water next to the Antarctic Continent and the Antarctic Convergence.

In summation it can be said that a general picture of the oceanic circulation consists of the water flowing northward in the upper layers of the ocean mixing with the deep waters of the northern oceans flowing south and then returning to the Antarctic region at intermediate levels within the oceans. This picture is of course complicated by the superimposition of many secondary circulations within this general flow.

All oceans, except perhaps the North Pacific, show this broad, general circulation pattern of deep waters flowing toward the Equator and the surface waters moving poleward to replace them.

Since the Arctic and the Subtropical Convergences of the Northern Hemisphere are not as well developed as their southern counterparts, the deep circulations within the northern oceans vary to a larger degree than those of the southern oceans.

CHAPTER 17

ADMINISTRATION, PUBLICATIONS, AND SUPPLY

The purpose of this chapter is to provide the Aerographer's Mate 3 or 2 with the knowledge necessary to accomplish administrative tasks, and clerical and supply duties, and with knowledge needed to find information in publications.

Aerographer's Mates 3 or 2 may be assigned to take care of records and reports either afloat or ashore. A thorough knowledge of administrative requirements, ordering supplies, and handling publications is essential for good performance in an assignment.

ADMINISTRATION

Administration means understanding the chain of command and various other relationships between weather units, and the procedures whereby the right people get the right information (that is, weather observations, forecasts, records, or reports) at the right time.

The term "unit" as used in this chapter means any weather office or personnel having the primary mission of providing weather service. These units may or may not be "detachments" under the command of various centrals and facilities of the Naval Weather Service. Shipboard units and most special types of units are not included in the "detachment" category.

AREAS OF METEOROLOGICAL RESPONSIBILITY

The Naval Weather Service system is organized to provide global forecast services to meet Navy environmental requirements and Department of Defense oceanographic requirements. The system embraces the Naval Weather Service and elements of the Operating Forces, Shore Establishment, and Navy Department to which oceanographic meteorological or weather observing personnel are assigned.

As military technologies have advanced and become more complex, naval operations have become more sensitive to the natural environment in which they are conducted. Because of this, the concurrent evolution of the present functional Naval Weather Service system has taken place.

Naval Weather Service Command (NAVWEASERVCOM)

At the time of writing this manual the NAVWEASERVCOM was being merged with the Oceanographer of the Navy to form the new command of Navy Oceanography and Meteorology (NAVOCEANMET) under a director. Implementing instructions as to the new command had not been received to include them in this manual. Personnel should refer to latest instructions for organizational changes, reporting procedures, responsibilities and etc.

Relationships With Other Commands

It is important that the Aerographer's Mate understand the relationships which exist between the Naval Weather Service and the naval commands with which he may become associated.

Detailed information on the relationships which exist between the NAVWEASERV and various commands may be found in the Manual of the Naval Weather Service Command, Volume One.

Other Relationships

The Naval Weather Service system is not self-sufficient with regard to the fulfillment of its mission. No single weather service is. The world's ocean-atmosphere environment must be observed and studied on a global scale. Cooperation and coordination on national, regional, and international levels are mandatory, particularly with respect to observing and exchanging coded information reflecting the system's continuously changing state. The U.S. Navy is an active participant in the World Meteorological Organization (WMO), an organization of international cooperation in meteorology.

NAVAL WEATHER UNITS

To carry out their assigned functions, weather units ashore and afloat are maintained with all major aviation units on certain types of combatant and auxiliary vessels, on certain fleet flagships, and at other naval activities ashore.

The trained enlisted and commissioned meteorological personnel assigned to a particular ship or station comprise the naval weather unit.

Detailing Aerographer's Mates to each ship or station is performed by the Bureau of Naval Personnel. The number of personnel provided to each naval weather unit depends upon the operational requirements placed upon the unit. The number of hours per day during which meteorological services must be available is a particularly important factor in determining personnel requirements.

WEATHER UNITS ASHORE

There are five basic types of weather units ashore:

1. Fleet Numerical Weather Central.
2. Fleet Weather Centrals.
3. Fleet Weather Facilities.
4. Naval Weather Service Facilities.
5. Naval Weather Service Command Detachments.

The centrals and facilities are structured to provide, collectively, global fleet support.

Fleet Numerical Weather Central (FLENUMWEACEN)

The Fleet Numerical Weather Central, Monterey, CA, is the operational hub of the Naval Weather Service (NAVWEASERV) system. It is globally-oriented to generate basic numerical (computer) products in support of the entire NAVWEASERV system and from which specific fleet support products and services are derived.

Fleet Weather Central (FLEWEACEN)

The Fleet Weather Centrals utilize the basic numerical products to provide specific fleet environmental support (less the polar regions). This support includes the fleet environmental broadcasts, as well as that support in response to specific requests by the operating forces. Each FLEWEACEN is oriented to a major ocean basin area.

Fleet Weather Facility (FLEWEAFAC)

Fleet Weather Facilities, within assigned local and/or functional areas of responsibility, supplement the direct fleet support provided by the FLEWEACENs. For example, FLEWEAFAC Suitland, MD, is oriented primarily to provide fleet environmental support in the polar regions, particularly sea ice forecasting, and to provide global meteorological satellite analysis and interpretation support to the FLEWEACENs.

Naval Weather Service Facility (NAVWEASERVFAC)

Naval Weather Service Facilities are oriented primarily to management functions, although they also provide local and aviation fleet forecast services. They command NAVWEASERV detachments and manage selected technical programs, thus permitting FLEWEACENs and FLEWEAFACs to concentrate more completely on operational support services.

Detachments of the Naval Weather Service

Detachments are established to provide locally-oriented support at stations and air stations, and to perform specific technical functions in support of the NAVWEASERV system.

NAVAL WEATHER SERVICE ENVIRONMENTAL DETACHMENT (NWSED).—NWSEDs are established under an Officer in Charge or Chief Petty Officer in Charge who reports to a designated NAVWEASERV central/facility. They are oriented to provide direct environmental support, including aviation and oceanographic services, within their local areas.

Detachments assigned to NAVWEASERVFAC Pensacola, FL, are oriented toward support of

Naval Air Training. Similarly, the detachments assigned to NAVWEASERVFAC Glenview, IL, primarily support the Naval Air Reserve program. Detachments providing data support and liaison functions primarily are assigned to FLENUMWEACEN Monterey, CA.

NAVAL WEATHER SERVICE DETACHMENT (NWSD).—NWSDs are oriented to provide specific technical support of the NAVWEASERV system. For example, NWSD Asheville, NC, provides climatological support to the Naval Weather Service. NWSD Asheville, NC, is under the command of FLEWEAFAC Suitland, MD.

NAVAL WEATHER SERVICE METEOROLOGICAL UNITS

Naval Weather Service Meteorological Units composed of varying numbers of meteorological personnel are assigned to staffs, ships, and activities according to the specific requirements for environmental support. These units are normally integral components of the commands to which they are assigned, and they are staffed and equipped in accordance with their designated functions.

PARTICIPATING UNITS

Ships, aircraft squadrons, and some shore activities to which no meteorological personnel are assigned are also elements of the Naval Weather Service in that they are direct contributors of environmental observations. The NAVWEASERV provides technical guidance and direction in the observing and reporting procedures to be employed by these units.

OBSERVATIONAL PROGRAMS

Requirements for taking environmental observations emanate from obligations to the Department of Defense, the Department of the Navy, and from agreements of mutual benefit between national and international agencies. NAVWEASERVCOMINST 3140.1( ) provides the minimum requirements for taking and recording observations by Navy and Military Sealift Command (MSC) ships.

Such additional and special weather and oceanographic observations and reporting schedules as may be required in support of fleet operations are promulgated in pertinent operation plans and orders. Requirements for increased frequency of weather reporting by ships at sea in specific areas, particularly in areas where tropical disturbances are suspected or known to exist, will be promulgated as necessary by the cognizant area or force commander.

WEATHER SERVICES

The very large and nearly continuous flow of data required to provide operational forecasts necessitates the use of high-speed data links and centralized computer processing. FLENUMWEACEN Monterey, CA, satisfies this requirement, and, in so doing, affords the forecaster with additional time for analytical thought and for application of scientific methods in the preparation of forecasts.

CENTRALIZATION CONCEPT

Hemispheric data are needed on a routine basis for forecasts beyond 36 to 48 hours. It is not feasible for most units to collect and process the volume of data necessary to meet their requirements for service. The FLEWEACENs, within assigned areas of responsibility, provide the smaller units with products that have been computer generated by the FLENUMWEACEN.

Utilization of Common Services

Environmental support ashore is provided by certain centrals and facilities and by all NWSEDs. This support is supplemented in some areas by Air Force services and, within the U.S., by services provided by the Federal Aviation Administration (FAA) and the National Oceanic and Atmospheric Administration (NOAA).

Common Services Provided by NAVWEASERV Units

Weather warnings of tropical phenomena (hurricanes, typhoons, etc.) are routinely provided to activities ashore by designated FLEWEACENs. Daily forecasts and warnings of extratropical destructive weather (high winds, thunderstorms, etc.) are routinely provided for the local area by the co-located NAVWEASERV activity.

Local and functional areas of responsibility are assigned and described in the U.S. Navy Meteorological and Oceanographic Support Manual, NAVWEASERVCOMINST 3140.1( ).

WEATHER BROADCASTS TO OPERATING FORCES

Most of the environmental support routinely required by fleet units is available on a regularly scheduled basis via normal Navy Communications channels. Support services tailored for specific operations are also available to ships at sea upon request to the cognizant central/facility.

Weather information is broadcast by Continuous Wave (CW), radioteletype (RATT), and radio facsimile. Schedules and frequencies are published in the Codes Manual, NAVAIR 50-1P-11; JANAP 195; and the Worldwide Marine Weather Broadcasts manual.

The following environmental products are routinely available to fleet units:

1. Wind warnings (oceanic areas).
2. High sea warnings.
3. Small craft warnings (harbor).
4. Storm surge (tidal) warnings (harbor).
5. Fleet operating area forecasts.
6. Area analyses and prognostic charts (meteorological and oceanographic).
7. Nuclear fallout warning/preburst prediction (provided when required).
8. Aviation weather (air stations and routes).
9. Local severe weather.
10. Satellite cloud photography (neph-analyses or photographs).

Additional information concerning weather warnings is provided by OPNAVINST 3140.24( ), NWP 50, various directives of the 3140- and 5400-series, SOPA instructions, and pertinent operation orders.

LOCAL METEOROLOGICAL SERVICES

Local Forecasts and Outlook

Local forecasts are intended for the use of ship or station personnel in planning local operations. They should contain a brief narrative summary of the major weather features that could be of interest to local recipients of the forecast. In addition, a general synopsis of expected developments for the local area during the forecast period should be included. Detailed forecasts of those elements of concern to the recipients of the forecasts (such as flying conditions, surface and upper winds, maximum and minimum temperatures, precipitation, icing, sea conditions, ceiling, visibility, and turbulence) should be included by periods as required locally. Include an outlook, if appropriate.

Due to varied requirements of ships and stations a standard form for local forecasts is not prescribed. Locally designed forms may be used.

The times at which local forecasts are issued are determined on the basis of the need for local operations.

Weather Services to Aviation

Routine weather services to aviation fall into the following categories:

1. Area forecasts.
2. Route forecasts.
3. Flight forecasts.
4. Terminal forecasts.
5. Weather briefing for flight clearance.
6. Flight documents.
7. Inflight weather services.

AREA FORECASTS FOR AVIATION.—Area forecasts for aviation refer to weather conditions for a given period within a specified area without reference to a particular flight or route. These forecasts are not provided routinely by Naval Weather Service units but may be required by appropriate commanders concerned with aircraft operations.

Area forecasts for aviation should be in plain language, utilizing appropriate ICAO phraseology. These forecasts are issued at such intervals as required. No format is prescribed but normally the area forecast contains the following information:

1. Area of coverage.
2. General description of the prognostic situation.
3. Clouds and weather.
4. Icing.
5. Turbulence.
6. Upper winds.
7. Outlook.

ROUTE FORECASTS.—Route forecasts refer to weather conditions for a given period along a route but not necessarily to a particular flight. Route forecasts are primarily for local use at a particular station or in a particular area and are prepared as directed by local authority. They may be combined with area or local forecasts for use in planning flight operations.

The information in a route forecast is essentially the same as in an area forecast, but is applied to the particular route for which the forecast is prepared.

Route forecasts exchanged on civil or international circuits in accordance with ICAO Regional Procedures are in the code specified for use in the region for which issued.

FLIGHT FORECASTS.—Flight forecasts refer to the weather conditions on successive stages of particular flights. These forecasts are similar to route forecasts except that they are prepared for separate and particular flights.

Flight forecasts may be prepared by the weather unit of one station for use by another station not having a sufficient number of qualified personnel to prepare these forecasts.

Flight forecasts may be verbal or written, depending on whether the specified flight requires a flight plan or not. For written flight forecasts, DD Form 175-1 is used and provides a comprehensive record of weather flight planning information for pilots and flight clearance authority. This flight weather briefing form includes entries for takeoff, en route, and terminal weather data. For instructions for completing this form refer to NAVWEASERVCOM Instruction 3145.1( ).

NAVWEASERVCOMINST 3140.53( ) provides instructions for preparation of a U.S. Navy Flight Weather Packet, which is issued when requested. The packet contains a Flight Forecast Folder CNWS Form 3140/25 (Appendix XIII) Flight Weather Briefing DD Form 175-1, HWD (horizontal weather depiction) -high or low level—and an upper wind chart; other data will be included upon request.

TERMINAL FORECASTS.—Terminal forecasts refer to weather conditions at air stations, or airports, for a given period, which may affect the landing or takeoff of aircraft. These forecasts are prepared and coded in accordance with NAVWEASERVCOMINST 3143.1( ).

FLIGHT BRIEFING AND CLEARANCE.—Flight briefing is the oral discussion with flight crews of the general and specific weather conditions which exist, or are expected, along the route of a flight and at the terminal. These briefings present all pertinent weather information necessary in the planning of flights or which may otherwise be of interest. Flight briefings should make available to flight crews pertinent information from current reports and weather maps, and from area, route, flight, and terminal forecasts. Weather units conducting flight briefings maintain complete displays of weather maps, weather reports, and forecasts for the perusal of flight personnel and for use in conducting flight briefings.

IN-FLIGHT WEATHER SERVICE.—Weather units provide such weather information as may be requested by aircraft in flight. In addition, these units are familiar with those in-flight weather services maintained by the Federal Aviation Administration and other government agencies in their area.

Selected Flight Service Stations (FSSs) having voice facilities on continuously operated radio ranges or radio beacons broadcast weather reports and other airways information at 15 minutes past each hour. In addition, all FSSs also provide direct pilot-to-weather briefer service. Details concerning these services may be found in the Airman's Information Manual.

Pilot-to-forecaster service (PFSV) employed extensively by the Air Weather Service of the Air Force is in use by selected Naval Weather Service units. Refer to the current edition of En Route-Supplement for the naval air stations where this service is available.

Ships operating within radio range of an airways communications station should, when appropriate, use it as a source of hourly weather reports by reception of scheduled broadcasts.

OTHER METEOROLOGICAL SERVICES

Climatological Services

The NAVWEASERV provides climatological services to the Navy through its NWSEDs, FLEWEACEN/FACs, NAVWEASERVFACs, and NWSD Asheville, NC.

NWSEDs and weather units afloat provide climatological studies for their local areas based upon existing publications and summaries. Local units will forward requests which are beyond their capabilities to the cognizant FLEWEACEN/FAC or NAVWEASERVFAC for action. Those requests for climatological studies or data beyond the capabilities of the FLEWEACEN/FAC or NAVWEASERVFAC shall be forwarded to DIRNAVOCEANMET. Validated requests will be processed by NWSD Asheville, NC.

Quality Assurance

Representatives of U.S. Meteorological Services (National Weather Service, Navy, and Air Force) comprise the National Climatic Center (NCC), Asheville, NC. The NCC is a repository of all weather records of the U.S. Meteorological Services and is equipped with modern electronic processing equipment and trained personnel for the climatological and research exploitation of weather records. The NWSD at Asheville manages the Navy's Climatological program at NCC. Its duties include conducting the quality assurance program of observational accuracy for Navy weather observing units, and processing climatological data for operational and research use.

Special Services

In addition to those services outlined in the preceding paragraphs, Naval Weather Service units provide the following special services when directed by competent authority:

1. Ballistic winds and densities.
2. Surf and swell forecasts.
3. Condensation trail information.
4. Q-factor information.
5. Radiological fallout diagrams.
6. Meteorological refractive effects upon radar wave propagation.
7. The meteorological information necessary for evaluation of the effects of sea and atmospheric conditions on sonar performance.
8. The meteorological information necessary for the delivery of special weapons (missiles, space craft, bombers, etc.).
9. Oceanographic information.
10. The meteorological information delineated in the various Allied Tactical Publications (ATP), Naval Warfare Publications (NWP), Naval Warfare Information Publications (NWIP), and addenda thereto.
11. Instruction of shipboard personnel in the proper techniques for observing, recording, and reporting weather.

METEOROLOGICAL REPORTS

Efficient administration, direction, operation, and coordination of the Naval Weather Service necessitates information about the operations of each of the weather units. Most of the information needed is obtained through the medium of regular reports on the operations of each of the weather units. Aerographer's Mates 3 or 2 can see that in making sound plans, a great deal of knowledge is necessary with regard to communications, supply, equipments, personnel, and other things. Regularly recurring reports supply the Naval Weather Service with this information. One of the AG's duties is to maintain the office files; and occasionally, when assigned to a 1-man billet, the AG may be required to submit these reports. This section of the chapter deals with the required reports, among which are the Monthly Meteorological Records Transmittal Form, NWSC Form 3140/6; Meteorological Station Report Description and Instrumentation, NWSC Form 3140/10( ); and the Monthly Personnel Summary.

METEOROLOGICAL RECORDS TRANSMITTAL FORM

The Naval Weather Service requires all weather observing meteorological units to complete and submit monthly the Meteorological Records Transmittal Form. Even during months when observations are temporarily discontinued (i.e., ship in yard, etc.), this report is required in order to maintain the continuity at the National Climatic Center. This form serves the function of a letter of transmittal for the monthly meteorological records. A completed U.S. Naval Weather Service Command Meteorological Records Transmittal Form is shown in Appendix XIV of this Rate Training Manual.

Preparation of Forms

This transmittal form is typed in duplicate each month, and the original is to be included with the packaged monthly meteorological records. A file copy is retained on board the meteorological unit. Entries are made on the form according to the directions on the back of the form.

Packaging of Records

The method of packaging is dependent on the number of types of forms a ship/station is required to submit. It is preferable to use a shipping container (fiber or cardboard) large enough to accommodate all forms without folding. However, it is extremely important to assemble the weather records in the proper order, which is explained on the back of the form.

Mailing

The transmittal form, with the weather records, is mailed as soon as possible after the end of the month, but not later than the 5th of the subsequent month. The packaged weather records are mailed via First Class mail to: Officer in Charge, NWSD, Federal Building, Asheville, NC 28801.

METEOROLOGICAL STATION DESCRIPTION AND INSTRUMENTATION REPORT

The Meteorological Station Description and Instrumentation report is prepared by all weather observing Meteorological Units. This report provides an annual description of the station's topography and instrument exposure. Refer to Appendix XV for an example of a completed report.

Preparation of Forms

This report is typed in triplicate and is prepared as of 1 January each year the ship or station is in commission. It is also submitted whenever a significant change occurs; i.e., change in instrument exposure, additional equipments, etc.

The size of the report sheet and blocks is in no way intended to limit submission of all pertinent information. Extra paper may be appended if required. Include commissioning or decommissioning of the ship or station and periods of expansion or curtailment of meteorological activities.

Entries on the form are made according to the instructions contained on the back of the form.

After the proper entries have been made and signatures included in block E of the original of each report it will be mailed to the Officer in Charge, NWSD, Asheville, NC. One copy of the report is sent to NAVOCEANMET, and the other copy is retained on board.

MONTHLY PERSONNEL SUMMARY

All activities of the Naval Weather Service must submit the Monthly Personnel Summary on the 1st day of each month. The forms are designated as NWSC Form 1080-4 (Rev 1/70).

The purpose of the report is to indicate the personnel allowed as compared to the personnel on board on the first day of each month.

The form is nearly self-explanatory. However, there are a number of abbreviations in the section titled Civilian: U. S. Nationals, which may require some clarification. For example:

FTP - Full time permanent personnel.
TPT - Temporary, part-time personnel.
UNG - Ungraded personnel.

After the Monthly Personnel Summary is completed it is signed by the Commanding Officer, Officer in Charge, or Chief Petty Officer in Charge or his representative and the original is forwarded to DIRNAVOCEANMET.

In addition, detachments must forward a copy of the report to their parent FLEWEACEN/FLEWEAFAC or NAVWEASERVFAC.

METEOROLOGICAL RECORDS

This section summarizes pertinent information with regard to records maintained in the Naval Weather Service. Among these records are the monthly meteorological records, forecasts, warnings, and equipment maintenance records.

MONTHLY METEOROLOGICAL RECORDS

The recorded observations, including surface, upper wind, and upper air observations, as well as the related instrument records, comprise the monthly meteorological records.

Table 17-1 contains an itemized list of these records with instructions for their distribution.

These instructions apply to all weather observing units except those attached to special missions or expeditions. Special weather units requiring retention of observations for use in preparation of operational reports or studies may delay submission of the records for 3 months.

The instruction for the completion of the individual records are contained in the appropriate chapters.

FORECASTS AND WARNINGS

Weather units retain on file for a period of 1 year all forecasts issued by the unit. Storm and small craft warnings are to be retained for 6 months.

MAINTENANCE RECORDS

Maintenance records on all meteorological instruments or equipments are primarily for local use. They are maintained for the purpose of abstracting information to provide NAESU or MOETLO or other repair technicians with a history of the equipment. A separate maintenance record should be kept for each piece of gear; it should be retained by the weather unit for at least the service life of the equipment involved.

AUTOGRAPHIC RECORDS

By autographic records is meant the traces and forms of mechanical, electrical, or electronic meteorological recording equipments. These autographic records are covered in chapters concerned with the equipment.

MISCELLANEOUS RECORDS

Other records maintained by a weather unit are forecast verification records, training records, logs, etc. Some of these may be for purely local use; others may be for official use.

Forecast verification records are kept in most weather offices in order to check performance of forecasters, to study forecasts which did not verify so that an error in thinking is not repeated, and to find techniques of forecasting which prove to be successful.

Training records are kept at each office to indicate the state of training for each individual to assure that eligible personnel qualify for advancement in rating, and to ensure that special tasks or jobs have a reserve of qualified personnel.

Supply and fiscal records take various forms, such as custody cards, files of material received, files of material on order, stock status files, and project files. It is important to maintain supply and fiscal records and logs accurately and up to date.

An office journal is kept at most stations wherein is logged all manner of administrative and need-to-know material. In smaller offices, a single log may take care of each item in the office. In larger offices, separate logs may be kept for passing information down the line, for the forecasters and their duties, and for the observers and their duties. In these logs are entered information which changes the daily routine, affects the uniform of the day, watch section changes, special duties, field days, storm warning issuances, forecast routings, personnel changes, and the like.

For the above-mentioned records and logs no specific format is prescribed, and the organization and requirements for these logs are local matters.

SUPPLY

The ordering and maintaining of supplies are important jobs in meteorology. Navy weather units must have the necessary supplies to carry out their duties and to be of effective service to the Navy.

At one time or another, most Aerographer's Mates are assigned the responsibility of maintaining supplies at the correct level and of ordering new supplies. It is the Aerographer's Mate's job to know and to be aware of much that is related to supply. For example, he must

Table 17-1.—Monthly Meteorological Records

Form title	FM number	Distribution instructions (See notes.)
SURFACE RECORDS		
Meteorological Records Transmittal Form	...	1,2,3
Surface Weather Observations (Land)	MF1-10	2,3
Surface Weather Observations (Ship)	MF1-11	2,3
Surface Instrumental Records All surface autographic records, except ceilometer record traces	...	2
UPPER WIND RECORDS		
Winds Aloft Computation Sheet (Constant time intervals) OpNav Form 3140-14	MF5-20N	2
Winds Aloft Plotting Chart OpNav Form 3140-27	...	...
Winds Aloft Computation Sheet (Constant height intervals) OpNav Form 3140-32	MF5-24N	2
UPPER AIR RECORDS		
Adiabatic Chart OpNav Form 3140-20	MF3-31A	2
Adiabatic Chart OpNav Form 3140-21	MF3-31B	2
Adiabatic Chart OpNav Form 3140-22	MF3-31C	2
Upper air instrument records, recorder record, radiosonde pressure calibration charts with available calibration data, and aerographs	...	2

(1) The records transmittal form is submitted each month by the weather unit while the ship or station is in commission.
(2) These forms comprise the MMR and are submitted each month in accordance with the instructions issued by NAVWEASERVCOM.
(3) Carbon copies should be retained until no longer required.

know what the allowances are, where and how he can procure the equipment and supplies, and how to keep cost and inventory records of them.

INITIAL OUTFITTING

Allowances for meteorological equipment, material, charts, forms, and technical publications are furnished to applicable activities, when commissioned, in accordance with Naval Air Systems Command Outfitting Directives and applicable NAVAIR Instructions, and CNO Directives.

Ship and stations authorized identical items as part of another assigned meteorological allowance (basic or augmenting) are not furnished duplicate issues at time of initial outfitting. Instead, a quantity equal to the largest amount as quoted by any of their assigned allowances is furnished, and that amount is the total amount required to be maintained.

REPLENISHMENT

Replacement or replenishment of all meteorological equipment and material is made in accordance with applicable portions of the NAVSUP Manual and NAVAIR (AIR-05F) Instructions and Notices.

Activities are responsible for maintaining complete allowances and for initiating requests to cover increased quantities or additional material resulting from the revision of allowances. However, serviceable equipment on hand must not be returned to stock in favor of requesting similar or more modern items indicated in the revised allowance list.

Major Equipment

Major equipment, not in excess of allowance, is requisitioned by submitting an appropriate requisition form to the nearest Meteorological Stock Point, listing items by stock number and nomenclature. Requisitions must bear an appropriate project code to indicate the reason for submission.

Requisitions for additional items or quantities of major equipment in excess of allowances are submitted with complete justification to Naval Air Systems Command (AIR-05F) via Naval Weather Service.

Other Supplies

All other supplies are requisitioned on the basis of individual station requirements and their current stock status in accordance with the applicable procedures for requisitioning referred to above. High usage items, consumed on a scheduled basis and requiring continuous replenishment, should be maintained at a 90-day stock level as determined by an activity's requirement. Additionally, a quantity, not to exceed an activity's 90-day requirement, is authorized to be on order to cover administrative delivery time from the distribution point. This is not to be construed as a restriction for fleet units preparing for extended deployment. Such units base their requirements on the length of deployment and the accessibility of materials.

Helium

Helium gas and its container are individual items of supply and therefore separately accountable. Gas cylinders are issued on a free exchange basis when practicable, an empty cylinder being exchanged for a full cylinder of the same stock number. Under such circumstances the only charge is for the gas issued from stores. When a full cylinder is issued and no empty cylinder is turned in for exchange, charge is made for the gas and cylinder, in accordance with Naval Supply Systems Command Manual directives.

Forms, Charts, and Publications

Weather plotting charts for all Department of Defense activities are printed and distributed by the Defense Mapping Agency Information Center. A list of available charts and requisitioning instructions is contained in NA 50-1G-518, DOD Catalog of Weather Plotting Charts.

Meteorological forms are requisitioned according to procedures described in NAVSUP 2002, Section I and Section II.

Meteorological Technical Publications are requisitioned according to procedures presented in NAVSUP 2002, Section VIII, Part C.

SPARE PARTS, ACCESSORIES, AND INSTRUCTION MANUALS

Aerographer's Mates do not requisition spare parts for most meteorological equipments; but they should have a knowledge of how spare parts are obtained and, in addition, how accessories and instruction manuals for these equipments are obtained.

Spare Parts

Spare parts for meteorological equipments are comprised of two types; e.g., parts peculiar to specific meteorological equipment, and parts common to other electronic equipments.

Spare parts are listed in applicable technical manuals and are furnished in accordance with Naval Air Systems Command Outfitting Directives when activities are commissioned or reactivated. Meteorological Units authorized equipment subsequent to commissioning or reactivation must initiate procurement.

Allowance of spare parts, is requisitioned by the cognizant Supply Officer and maintained in stock as required in support of the meteorological equipment operated by the station.

When required, parts common to other electronic equipment, if not stocked locally, are requisitioned through the local supply office for proper channeling.

Accessories

Unless accessories are furnished as part of the complete equipment they are not initially provided.

Instruction Manuals

Instruction manuals, where required, are generally packed with the equipment. In instances in which necessary maintenance parts, accessories, or instruction manuals for items are not provided but are required, an analysis of such requirements, including detailed lists of items, should be made the subject of a report to Commander, Naval Air Systems Command (AIR-05F).

FAILED OR UNSATISFACTORY METEOROLOGICAL EQUIPMENT

Unsatisfactory parts or equipment will be reported in accordance with OPNAVINST 4790.2( ). Reports of deficiencies will be submitted utilizing OPNAV Form 4790/47.

Material in this category is turned in complete, including all components and accessories originally furnished under the stock number (less ink and/or charts for recording equipment). If required, a replacement item may be obtained prior to turning in the unsatisfactory or defective item by submitting a requisition and stating justification to the nearest Meteorological Stock Point.

Meteorological equipment which is damaged, worn, or faulty and beyond local repair capability shall be shipped to the Supply Officer, Naval Air Station, Alameda, CA, or the Naval Air Station, Norfolk, VA, whichever is nearer, in accordance with NAVSUP Manual, Paragraph 26080. Each item will be tagged with the stock number, nomenclature, and marked "Meteorological Material for Repair."

EXCESS MATERIAL

Meteorological equipment and supplies in excess of requirements and applicable allowance are returned to the nearest Meteorological Stock Point, if in ready for issue (RFI) condition. Equipment not in RFI condition is disposed of in the same manner as failed or unsatisfactory meteorological equipment.

METEOROLOGICAL DISTRIBUTION POINTS

The following Reporting Stock Points have been designated as distribution channels for meteorological material, including equipment and related accessories and spare parts under the cognizance of ASO Philadelphia.

1. Naval Supply Center, Oakland, CA.
2. Naval Supply Center, Norfolk, VA.
3. Naval Supply Depot, Subic Bay, R.P.
4. Naval Air Station, Barbers Point, HI.
5. Naval Air Station, Alameda, CA.
6. Naval Air Station, Norfolk, VA.

The distribution point for naval publications and form is: Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

REQUISITION PROCEDURES

Replenishment refers to obtaining new supplies when old supplies are consumed or rendered useless. It involves priorities for ordering, accountability for received materials, direct local procurement, allotments, and obligations. By far, the greatest amount of activity centers around the simple ordering of supplies required on a routine basis. This ordering is accomplished through the MILSTRIP system for ordering supplies. MILSTRIP stands for Military Standard Requisitioning and Issue Procedures.

Stock replenishment by a weather office is made by station requisition to the station's supply office. That office in turn either issues the material from stock on hand or orders the material from the appropriate agency.

To order supplies, use one of the DD 1348 forms; these forms are the forms used in the MILSTRIP. The purpose of MILSTRIP is to standardize forms, formats, codes, procedures, and priority systems, and to provide a common supply language and more effective supply system operations. It provides a single requisitioning and issue system for use by all services which will provide more effective and efficient system management.

MILSTRIP was designed to provide complete coverage for supply transactions affecting the 3,700,000 stock items in the entire Department of Defense supply system, so that a transaction can be processed without change by any inventory manager and/or stock point.

MILSTRIP Forms

The Release/Receipt Document, DD Form 1348-1, is for material movement (shipping) only.

The DD Form 1348m (single card) is used as the requisition document by all activities having key punch capability. Activities which do not have key punch capability prepare DD Form 1348 manually, and hand-carry or mail the requisitions to the supporting activity. The DD Form 1348 replaces many forms because it is used for almost all requisitioning and followup actions.

The six-part DD Form 1348 is identical to the 1348m, except it has provisions for carbon copies. Further, it is filled in by typewriter or ballpoint pen. The form carries columns for all the essential information which goes into a requisition, and all this information is coded according to standard codes as published and maintained in the supply department of your ship or station. All Navy activities use these various codes. The manner of filling in the form is not discussed here because the details for completing vary from station to station or ship to ship and are subject to rapid change. Your primary concern is the correct stock number, priority, unit of issue, demand of item, quantity, and requisition delivery date.

Normally, the correct stock number is found in the Master Cross Reference List (MCRL), the Navy Management Data List (NMDL), or in the general stock catalogs which are kept in supply. For most of the frequently used items, the stock numbers should be in your supply logbook. Each stock number should be verified in the MCRL and the NMDL prior to requisitioning.

Priorities are determined by code. The unit of issue is furnished in the stock catalog, as is the quantity. The delivery date is also governed by code.

Accountability should not greatly concern you at the AG 3 and 2 levels. Most of the material you order will be consumable, with Code C. Other material will have an accountability code which may require a custody card.

Self-Service Store (SERVMART)

SERVMARTs eliminate the need for formal itemized request documents. Frequently, a "credit card" is issued to the meteorological supply PO, as required, to draw necessary supplies. Otherwise a DD Form 1348 is prepared with accounting data and "SERVMART" indicated for nomenclature. Final cost is entered by the "SERVMART' after material is drawn. Procedures vary greatly with activities.

The SERVMART stocks items for which there is a constant demand. These items are individually marked and displayed in counter-high bins for convenient self-service selection. Issue accountability is recorded by means of a cash register type sales slip which must be returned to the meteorological activity along with the credit card, or completed DD Form 1348.

Direct Local Procurement

At times it will be necessary to purchase items directly from local suppliers. There are many rules and regulations governing this procedure, and they are not treated here. Such procurements are generally limited to items used in an emergency, or items which are not stocked in the Navy supply system; they must also meet certain cost limitations.

As a general rule, a requisition is submitted to the local supply department citing all necessary descriptive information and a suggested source of supply. The local supply department then prepares the appropriate documents and makes the actual purchase from the commercial supplier.

Publications and Forms

Requisitions for publications and forms listed in NAVSUP 2002 are submitted on DD Form 1348 ONLY, and bear the National Stock Number.

MISCELLANEOUS SUPPLY PROCEDURES

Supply involves more than merely making out requisition forms when you need something, and signing a document when you get something, It is necessary for the Aerographer's Mates 3 and 2 to have at least a basic knowledge of NSA and APA material, National Stock Numbers, NSN Operating Budgets (OB), Operating Targets (OPTARS), obligations, inventory, and surveys.

Navy Stock Account (NSA)

The NSA comprises all material purchased with capital from the Naval Stock Fund (NSF) and held in store awaiting issue.

When activities requisition NSA items, the cost of the items is deducted from the activity's applicable quarterly OPTAR, and this amount is credited to NSF. This creates a revolving cycle of purchasing, storing, and issuing of material which keeps the combined assets of NSF and NSA at a constant level.

Stock numbers prefixed by odd numeric designators are NSA items.

Appropriation Purchases Account (APA)

APA consists of material which has been procured and paid for out of funds taken from the annual appropriations and held in store awaiting issue. Issues of APA items are NOT chargeable against any local OB or OPTAR.

To determine the amount of money the Navy requests Congress to appropriate, each Systems Command in the Navy estimates from past usage data the amount of certain materials that will be needed to operate for the succeeding year. For example, Naval Air Systems Command knows how many 100-gram pilot balloons the Naval Weather Service normally uses. They will request, in the appropriation, enough money to procure the succeeding year's supply of 100-gram balloons.

Stock numbers prefixed by even numeric designators are APA items.

OPERATING BUDGETS AND OPERATING TARGETS (OB/OPTARS)

Under the Financial Management of Resources program (RMS) effective 1 July 1968, the Department of Defense has determined that management will be improved if the financing of an activity is related to the total cost of the task or mission assigned, and if the costs are recognized and recorded against the budget at the time they occur instead of when they are ordered or paid.

The following sections explain the operating budget and the operating target (OPTAR).

Operating Budget

An operating budget is the annual budget of an activity. This budget contains estimates of the total value of all resources required for the performance of its mission, including reimbursable work or services for others. For example, NAVWEASERVFAC Pensacola is required to submit an operating budget that will include funds to support the various detachments under its command.

Operating Target

A NAVWEASERV commanding officer may establish an operating target (OPTAR) for a subordinate unit. This unit is then authorized to cite the commanding officer's expense operating budget to finance its requirements. For example, NAVWEASERVFAC Pensacola establishes an OPTAR for NWSED Memphis.

It is mandatory that auditable records be maintained by the OPTAR holder which show the value of transactions incurred and the remaining available funds of the OPTAR.

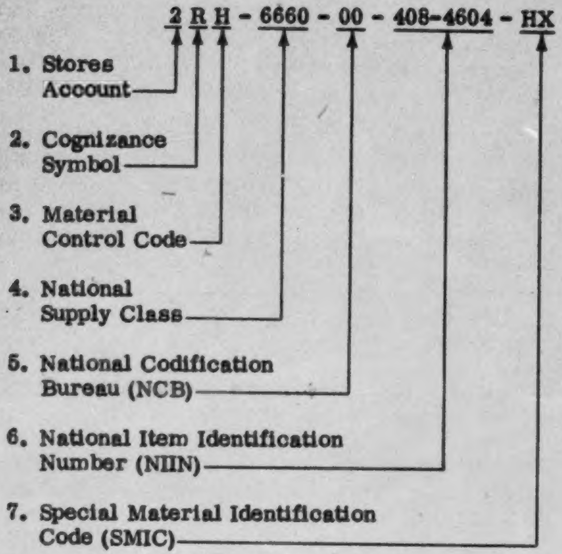
Normally at shore stations, most operating expenses and supplies are paid for out of the weather unit's OPTAR except for major equipments and maintenance of spaces which are paid for by the host command. Aboard ship, most expenses and supplies are paid for out of the funds allocated to the division from the ship's OPTAR, which derive from the type commander's operating budget.

MATERIAL IDENTIFICATION

As a primary signatory to NATO Standardization Agreements, the United States has adopted the NATO stock-numbering system. The cataloging system developed by the Department of Defense is such that it identifies with one stock number any item of supply that is carried in any or all governmental agencies of NATO. In the procurement of material it is normally necessary to identify your material requirement in the medium understandable to the supply system — the National Stock Number.

NATIONAL STOCK NUMBER (NSN)

The NSN consists of a 13-digit number. ASO uses NSNs with prefixes composed of three characters and suffixes composed of two characters. When the prefixes and suffixes are used, the NSN becomes a coded NSN; an example follows:


2 R H - 6660 - 00 - 408-4604 - HX
1. Stores Account
2. Cognizance Symbol
3. Material Control Code
4. National Supply Class
5. National Codification Bureau (NCB)
6. National Item Identification Number (NIIN)
7. Special Material Identification Code (SMIC)

The letters and numbers used in the National Stock Number are explained in the following paragraphs:

1. Stores Account. This number was explained in preceding paragraphs.

2. Cognizance Symbol. The main cognizance symbols for meteorological items are "R" (items controlled by ASO) and "V" (items controlled by NAVAIR). The cognizance symbol determines the controlling agency.

3. Material Control Code. The identification of the Material Control Code will aid in determining whether an item is to be repaired by a designated Naval Air Rework Facility (NARF) on a scheduled basis or if repair is to be accomplished by local repair facilities. In cases where the item is designated for local repair, but cannot be repaired locally, the item should be screened for salvageable material prior to final disposal action.

4. National Supply Class. This number is made up of the group code and the national supply classification code (NSC). It is composed of four digits. It is significant because it relates the item of supply to other items of supply in the same supply classification; for example, most meteorological materials are in the 66 group.

5. National Codification Bureau (NCB). This code is a 2-digit number designating the NATO country which cataloged the item. The United States is designated by the code "00" or "01."

6. National Item Identification Number (NIIN). This number is comprised of seven digits and further identifies the item in the stock numbering system. It serves to symbolize and fix the identity of the individual item of supply and to differentiate it from others.

7. Special Material Identification Code (SMIC). This code is suffixed to each National Stock Number used by the Naval Aeronautical Supply Organization. SMIC is used to indicate the management and reporting segment of the inventory to which the stock number is assigned. It provides a means for segmentizing the inventory to keep peculiar parts with the assemblies on which used and thereby providing for efficient procurement, inventory reporting and control, financial reporting, storage and issue.

SMIC consists of two symbols — for example, HX (meteorological equipment). SMIC, as well as the other required codes, should always be shown with the stock number to ensure proper handling within the Naval Aeronautical Supply Organization.

INVENTORY

The term inventory, as used by Aerographer's Mates, applies to the total amount of an item physically within the weather office spaces and under the control of the meteorological officer.

Inventory aboard ship is necessary to ensure that ships have a well-rounded stock of material on board at all times to sustain operations for a maximum period of time. In order to do this, effective inventory procedures must be maintained rigidly for all items in stock.

Inventory ashore is equally as important as aboard ship. At shore stations, the quantity of material on hand conforms to the station allowances prescribed by applicable allowance lists.

A good practice to follow, both ashore and aboard ship, is to maintain a monthly inventory on all consumable supplies and other materials. By doing this, the Aerographer's Mate knows the amount of each item that he has in stock at all times. Consequently, he can submit requests at the proper time to allow for the lead time between the submission of a request and the delivery of the material.

A suggested method to follow in maintaining a weather office inventory is to fill out a NAVSUP Form 460 for each item in the custody of the weather office. File these forms in a Kardex file in alphabetical order. This file gives the Aerographer's Mate a ready reference as to the status of any item for which the weather office is responsible.

OBLIGATIONS

Obligations against an OB/OPTAR consist of unfilled orders, which will be a proper charge against the OB/OPTAR upon receipt of the material.

It is a very good practice to maintain an obligation file on all NSA requests. This file shows at a glance the amount of the quarterly OB/OPTAR that is expended and the amount still obligated.

After a requisition document (DD Form 1348) has been prepared and entered as an obligation on the OB/OPTAR record, the retained copy should be placed in the obligation file in numerical order. The total of the 1348s in the obligation file should agree at all times with the total shown in the obligation column of the OB/OPTAR record. Upon receipt of a priced 1348 from the supplying activity after receipt of material, the obligation price is credited back to the OPTAR; then the actual price is posted. This transaction then becomes an expense item. The priced copy of the 1348 received from the supplying activity is then filed and the priced obligation copy is removed from the files and discarded.

SURVEYS

Rules and regulations governing surveys and the responsibility connected with the accounting for government property is of primary importance to every man in the naval service. A survey is the procedure required by Navy Regulations when property must be reevaluated or expended from the records due to loss, damage, deterioration, or normal wear. The survey request provides a record showing the cause, condition, responsibility, recommendation for disposition, and authority to expend material from the records. Survey Request, Report, and Expenditure (NAVSUP Form 154) is used to survey property other than survey due to discrepancies incident to shipment of material.

Aerographer's Mates 3 and 2 are not ordinarily required to handle surveys. If you should find yourself in a position in which a survey of equipment in your custody is indicated or required, see your leading chief or your division officer and request his assistance.

SUMMARY

Supply is a complex matter in the Navy. It pays to keep abreast of everything going on with respect to changes in the supply system, or in the methods for requisitioning materials. The treatment here has been brief by necessity, but it should have given you some insight into supply. The station instructions with regard to supply are important; study these well as you go from station to station. Although the Navy operates on a uniform system, there are minor variations, and knowing these will make the difference between smooth supply operations and a headache.

PUBLICATIONS

In the Naval Weather Service there are numerous publications with which the Aerographer's Mate must be acquainted.

It is beyond the scope of this manual to describe, or even mention by name, all of the publications used in meteorology. Therefore, this section is devoted to a brief description of a few of the basic publications and directives pertaining to the meteorological program of the U.S. Navy.

MANUAL OF THE NAVAL WEATHER SERVICE COMMAND, NAVWEASERVCOMINST 5400.1

The Manual of the Naval Weather Service Command is intended to provide direction for the management and operation of the Naval Weather Service. It also provides information and guidance for the performance of meteorological and oceanographic related functions within the Department of the Navy.

The manual is the basic reference to the policies and directives of the DIRNAVOCEANMET for operation of the Naval Weather Service system.

The manual consists of two volumes. Volume One is comprised of five parts which provide information on organization, meteorological and oceanographic operations, meteorological support functions, and management. Volume Two (Appendices) provides additional information on each section of Volume One. Volume Two also provides a bibliography for each reference within the text as well as a biographical resume of the Naval Weather Service.

U.S. NAVY METEOROLOGICAL AND OCEANOGRAPHIC SUPPORT MANUAL, NAVWEASERVCOMINST 3140.1( )

The U.S. Navy Meteorological and Oceanographic Support Manual is provided as an authoritative reference for use of operational units of the Naval Weather Service. It consolidates, for operational use, some of the more pertinent directive material. The Support Manual outlines the NAVWEASERV organization and describes the environmental services and support available to all ships and stations. It is also meant to consolidate existing requirements for environmental observing and reporting and provides authority for meteorological equipment allowances.

FEDERAL METEOROLOGICAL HANDBOOKS (FMH)

Working Groups comprising personnel from the National Weather Service, Federal Aviation Administration, Navy, and Air Force are responsible for preparing handbooks relating to meteorological matters which are common to all Federal agencies. These Handbooks, entitled "Federal Meteorological Handbooks," contain meteorological practices and procedures common to all Federal agencies. Individual agencies may issue addenda to cover policies peculiar to their agency. However, these addenda apply only to the issuing agency. Changes to the FMHs will be coordinated and issued by the Working Groups responsbile for the handbooks. These changes will be made to the handbooks immediately and the proper entry made on the handbook's Record of Changes page. The NAVAIR number of each FMH is directly related to the FMH number; i.e., FMH No. 1 is NAVAIR 50-1D-1, FMH No. 2 is NAVAIR 50-1D-2, etc. A brief description of the effective FMHs follows.

FMH No. 1, Surface Observations
NAVAIR 50-1D-1

This handbook provides detailed information and instructions on surface observations. It describes the Meteorological elements and explains how they are observed and how they are recorded.

FMH No. 3, Radiosonde Observations
NAVAIR 50-1D-3

This handbook contains instructions for taking and recording radiosonde observations.

FMH No. 5, Winds Aloft Observations
NAVAIR 50-1D-5

This handbook provides instructions for observing and recording winds aloft observations.

Manual of Barometry

The Manual of Barometry, NW 50-1D-510, contains a comprehensive background on barometry; a description of the various pressure measuring devices and their related equipment; pressure-instrument calibration methods; methods of computing the required pressure data; and a compilation of tables used in pressure computations.

Federal Meteorological Handbooks for Codes

Three handbooks for codes have been issued as Federal Meteorological Handbooks to meet the requirement that all United States meteorological agencies use one set of publications containing coding instructions. They are FMH No. 2, Synoptic Code, NAVAIR 50-1D-2; FMH No. 4, Radiosonde Code, NAVAIR 50-1D-4; FMH No. 6, Winds Aloft Code, NAVAIR 50-1D-6.

NAVAL WEATHER SERVICE COMMAND INSTRUCTIONS (NAVWEASERVCOMINST)

NAVWEASERVCOM Instruction which emanated from the office of the Commander, Naval Weather Service Command, will remain in effect until cancelled or superseded by new instructions from the Director Naval Oceanography and Meteorology. These instructions deal with Naval Weather Service matters, and may not necessarily be meteorological in nature. Table 17-2 lists some (but not all) of the subject areas of interest to Aerographer's Mates.

INTERNATIONAL CLOUD ATLAS

The International Cloud Atlas (Abridged), NW 50-1D-509, is a world Meteorological Organization publication, which was prepared for the purpose of meeting the day-to-day needs of the meteorological observers at surface stations the world over. It contains a representative selection of photographs from the complete cloud atlas, together with a brief descriptive and explanatory text of clouds and the techniques for observing and reporting them.

Table 17-2.—NAVWEASERVCOMINST subject areas

Number	Subject area
3140	Weather Services
3141	Weather Operations and Plans
3142	Weather Maps and Charts
3143	Weather Codes
3144	Weather Observations and Reconnaissance
3145	Weather Forecasts, Warnings, and Advisories
3146	Climatology and Weather Records
3147	Weather Phenomena

The International Cloud Atlas is a comprehensive reference work, and serves as the standard for observing and reporting clouds for all the nation's weather services.

METEOROLOGICAL TECHNICAL PUBLICATIONS

Technical publications for the basic meteorological equipment are prepared under the direction of the Naval Air Systems Command, or under the direction of the service having prime responsibility for the equipment. These publications issued in the form of technical manuals, instruction books, or handbooks discuss the operating instructions and maintenance procedures for the equipment involved. Each type of equipment is covered by a separate publication.

Most of the technical publications for instruments or equipments carry a NAVAIR number in the 50 series; some do not and must be searched for in other sections of the publications stock list. For instance, the instrument manuals dealing with the AN/GMD-2 Set carry a NAVAIR 16 number, and are not listed in the section with the meteorological equipments.

In addition to technical publications dealing with meteorological instruments and equipments, there are other types, such as meteorological texts, works on climatology, procedures, etc. Most of these publications bear a NAVAIR 50 or a NW 50 number and can be found in one single section of the publications stock list, NAVSUP 2002.

NAVY STOCK LIST OF FORMS AND PUBLICATIONS

The Navy Stock List of Forms and Publications, Cognizance Symbol I, NAVSUP Publication 2002, lists technical publications and forms available to naval aviation activities.

The forms and publications stock lists contain a complete numerical listing of all available naval aeronautical publications distributed by the Naval Air Systems Command and stocked for issue as of the date of the publication.

The forms and publications stock list is revised periodically by the issuance of supplements. The supplements are organized in the same manner as the basic list; thus, new publications or revisions to old ones are easily located and identified.

The forms and publications stock lists are the basic guide as to what is current in the way of meteorological publications, and should be checked frequently, along with the supplements issued thereto.

CODES MANUAL (NAVAIR 50-1P-11)

The Codes Manual is separated into two parts. Part I contains World Meteorological Organization (WMO) international codes for meteorological data and other geo-physical data relating to meteorology. Part II contains a catalog of synoptic broadcasts which includes information for marine areas. The synoptic broadcasts are presented by ocean basin.

AIR ALMANAC

The Air Almanac is produced jointly by the Royal Greenwich Observatory and the United States Naval Observatory, but is printed separately in England and in the United States. The purpose of the Air Almanac is to provide in a convenient form the astronomical data required for air navigation.

Among other things, the Air Almanac permits the computation of sunrise, sunset, moonrise, moonset, and twilight. The operations required to compute the desired astronomical data are given in the instructions in the book. These instructions are simple, as are the procedures for computing the various data. No special training is required.

TIDE TABLES

Tide tables are prepared by the National Ocean Survey to furnish information on predicted times and heights of tides for each day of the year at various locations (usually harbors and ports). These places are known as reference stations.

By applying certain corrections given in the tables, the approximate times and heights of tides may be determined for other locations.

There are four volumes of tide tables covering the following areas: East Coast, North and South America; West Coast, North and South America; Europe and West Coast of Africa; Central and Western Pacific and Indian Oceans. These tables are revised annually.

The tide tables can be ordered through the Oceanographic Office.

GUIDE TO STANDARD WEATHER SUMMARIES, NAVAIR 50-1C-534

The Guide to Standard Weather Summaries is prepared by NWSD, Asheville, NC, by direction of DIRNAVOCEANMET.

This publication provides a listing of published and unpublished climatological summaries available from the appropriate agencies in the Federal Building, Asheville, NC. Copies of any of the weather summaries described in the Guide to Standard Weather Summaries, and copies of published NOAA summaries, can be provided to meet requirements of Navy activities. Requests should be submitted in accordance with information contained in the Manual of the Naval Weather Service Command, to the Director, Navy Oceanography and Meteorology, with a copy to the Officer in Charge, Naval Weather Service Detachment, Asheville.

NAVY DIRECTIVES SYSTEM

The Navy Directives System is used throughout the Navy for the issuance of nontechnical directive-type releases. Some of these prescribe policy, organization, and methods, or procedures; others contain general information. This directives system provides a uniform plan for issuing and maintaining directives. Conformance to the system is required of all Systems Commands, offices, activities, and commands of the Navy. Two types of releases are authorized under the plan—Instructions and Notices.

Information pertaining to action of a continuing nature is contained in Instructions. An Instruction has permanent reference value and is effective until the originator supersedes or cancels it. Notices contain information pertaining to action of a one-time nature. A Notice does not have permanent reference value and contains provisions for its own cancellation.

For reasons of identification and accurate filing, all directives can be recognized by the issuing authority's authorized abbreviation, the type of directive (Instruction or Notice), a standard subject identification code number; and in the case of Instructions only, a consecutive number. Because of their temporary nature, the consecutive number is not assigned to

Notices. This information is assigned by the originator and is placed on each page of the release.

The manner of numbering and identifying directives can be better understood by considering a typical identifier:

SECNAV	INST	5215.1A
(a)	(b)	(c) (d)

(a) The authorized abbreviation of the issuing authority of the directive.

(b) Type of directive (in this case an Instruction).

(c) The subject number, which is determined by the subject matter of the directive and is obtained from the Navy Standard Subject Identification Codes, SECNAVINST 5210.11( ).

(d) Following the period is the consecutive number, found only on Instructions.

An issuing authority would assign consecutive numbers to those consecutive instructions with the same Standard Subject Identification Code.

In the example above, the Standard Subject Identification Code 5215 concerns Issuance Systems. If the issuing authority, SECNAV, issued additional Instructions dealing with issuance systems they would be assigned number 5215.2, 5215.3, 5215.4, etc. The capital letter A following the subject classification and consecutive number indicates that this Instruction has been revised once; the capital letter B indicates the second revision, etc.

Standard Subject Identification Codes

The Navy Standard Subject Identification Codes SECNAVINST 5210.11( ), prescribes the subject identification system that must be used throughout the Department of the Navy as the standard system for subject identification and filing correspondence and other documents by subjects.

The Navy Standard Subject Identification Codes utilizes a table of numbers corresponding to a table of subjects. Broad subject areas are assigned a range of numbers. A specific subject carries a specific number within the subject area group.

For example, the numbers between 1000-1999 deal with military personnel. Number 1430 deals specifically with advancement in rate or rating of enlisted personnel. The subject classification is thoroughly indexed and can be easily used. For instance, given the number, it is easy to find the corresponding subject; given the subject it is easy to find the corresponding number. The system is based on the Navy Directives System as far as organization of subject areas is concerned.

Naval Air Systems Command Instructions

Naval Air Systems Command Instructions and Notices dealing primarily with meteorological equipments and related matters (their procurement, maintenance, operation, and the like) are usually in the 13950 series.

Maintenance of Navy Directives

To find out whether or not the particular Instruction is up to date, check the Directives Issuance System Check List. This index is identified as NAVPUB Instruction 5215.3.

NAVAL WEATHER SERVICE NEWSLETTER

The Naval Weather Service Newsletter is published quarterly by the NAVWEASERV. It is a publication that is designed to carry shoptalk, notices of new developments, personnel changes, publication information, etc. Though the opinions expressed are not necessarily those of the Navy Department, it is an informative publication.

NAVY CORRESPONDENCE MANUAL

The Navy Correspondence Manual prescribes policies and outlines procedures for the preparation of correspondence in the Department of the Navy. These policies and procedures are followed unless prescribed otherwise by the Secretary of the Navy or by his authority.

The selection of the proper communication for use in transmitting information is of special importance in Navy operations. Listed below are some of the types of correspondence and their uses:

1. Naval Letter. The naval letter is used by all activities of the Department of the Navy as a formal means of intranaval communication. It may be used also in addressing other agencies, either governmental or nongovernmental, which are familiar with the style. (See fig. 17-1.)

2. Joint Letter. When officials of two or more activities need to issue a letter concerning a particular subject of common interest to the activities, a joint letter is prepared. It may be directed to one addressee, or to two or more addressees identified separately or as a group.

3. Speedletter. A speedletter is a form of naval correspondence used for urgent communication which does not require electrical transmission. It is not used for directives. The primary purpose of the speedletter is to call attention to the communication, so that it will be handled as promptly as possible by the recipient.

4. Memorandum. A memorandum is a form of naval correspondence used for informal communications within and between headquarters components of the Navy Department, between fleet and force commanders and units of command under their jurisdiction, and within a field activity. It may be directed to one or more addressees.

Figure 17-1 illustrates in detail the format of naval letters. Because this format may change slightly from time to time, the latest Navy Correspondence Manual should be consulted.

The naval letter is perhaps the most formal type of correspondence used by the Navy, but this does not mean that its content cannot be simple. Avoid long sentences and long words where short sentences and short words convey the same meaning. Each paragraph should contain one complete thought expressed in logical sequence. Tables, diagrams, and sketches should be included as enclosures if necessary to add to the clarity of the letter.

If the letter is in reply to another letter, it should answer all expressed and implied questions.

A rough draft of any letter should ordinarily be typed double space for the responsible officer to look over and revise according to his wishes.

SECURITY

It has been said, "There is no such thing as peace. It is only the interim between wars." A study of history indicates that most wars are carefully planned long before the first shot is fired. During this so called peaceful period, nations are engaged in the collection and evaluation of all forms of intelligence material from potential enemies.

In peacetime, people tend to relax; security is sometimes ignored. This tendency makes it easier for a potential enemy to gather information concerning our capabilities and intentions.

PURPOSE OF THE SECURITY PROGRAM

Basically, the purpose of the security program is to protect classified material from unauthorized disclosure.

It is the responsibility of every person in the Navy to safeguard classified information. The AG must be especially vigilant since he frequently comes in contact with classified material.

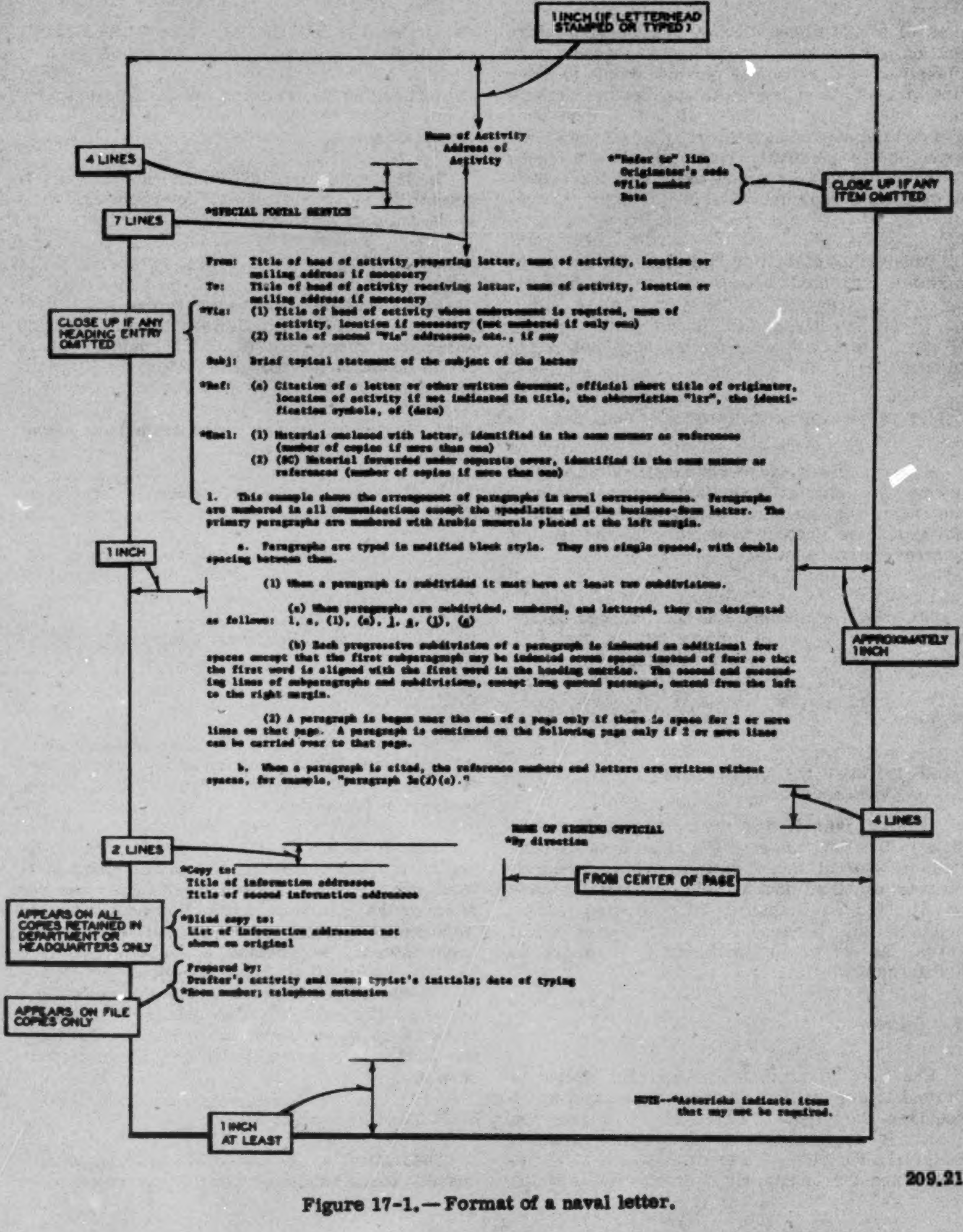
SECURITY MANUAL

The Department of the Navy Information Security Program Regulation, OPNAVINST 5510.1( ), is designed to furnish standards for handling classified matters. The manual itself does not guarantee security but makes security more readily attainable. Detailed instructions pertaining to the handling of classified matter can be found in this manual.

It must be remembered, however, that there is no adequate substitute for continuous day-to-day practice in the proper methods of handling classified material.

SECURITY PRINCIPLE

The Department of Defense employs a security formula which is simple in principle. It is based on the theory of circulation control—the


1 INCH (IF LETTERHEAD STAMPED OR TYPED)
4 LINES
7 LINES
CLOSE UP IF ANY ITEM OMITTED
CLOSE UP IF ANY HEADING ENTRY OMITTED
1 INCH
APPROXIMATELY 1 INCH
4 LINES
2 LINES
FROM CENTER OF PAGE
APPEARS ON ALL COPIES RETAINED IN DEPARTMENT OR HEADQUARTERS ONLY
APPEARS ON FILE COPIES ONLY
1 INCH AT LEAST

Name of Activity
Address of
Activity

*"Refer to" line
Originator's code
*File number
Date

*SPECIAL POSTAL SERVICE

From: Title of head of activity preparing letter, name of activity, location or mailing address if necessary
To: Title of head of activity receiving letter, name of activity, location or mailing address if necessary
*Via: (1) Title of head of activity whose endorsement is required, name of activity, location if necessary (not numbered if only one)
(2) Title of second "Via" addressee, etc., if any

Subj: Brief topical statement of the subject of the letter

*Ref: (a) Citation of a letter or other written document, official short title of originator, location of activity if not indicated in title, the abbreviation "ltr", the identification symbols, of (date)

*Encl: (1) Material enclosed with letter, identified in the same manner as references (number of copies if more than one)
(2) (SC) Material forwarded under separate cover, identified in the same manner as references (number of copies if more than one)

1. This example shows the arrangement of paragraphs in naval correspondence. Paragraphs are numbered in all communications except the speedletter and the business-form letter. The primary paragraphs are numbered with Arabic numerals placed at the left margin.

a. Paragraphs are typed in modified block style. They are single spaced, with double spacing between them.

(1) When a paragraph is subdivided it must have at least two subdivisions.

(a) When paragraphs are subdivided, numbered, and lettered, they are designated as follows: 1, a, (1), (a), 1, a, (1), (a)

(b) Each progressive subdivision of a paragraph is indented an additional four spaces except that the first subparagraph may be indented seven spaces instead of four so that the first word is aligned with the first word in the heading entries. The second and succeeding lines of subparagraphs and subdivisions, except long quoted passages, extend from the left to the right margin.

(2) A paragraph is begun near the end of a page only if there is space for 2 or more lines on that page. A paragraph is continued on the following page only if 2 or more lines can be carried over to that page.

b. When a paragraph is cited, the reference numbers and letters are written without spaces, for example, "paragraph 1a(2)(a)."

NAME OF SIGNING OFFICIAL
*By direction

*Copy to:
Title of information addressee
Title of second information addressee

*Blind copy to:
List of information addressees not
shown on original

Prepared by:
Drafter's activity and name; typist's initials; date of typing
*Room number; telephone extension

NOTE--*Asterisks indicate items
that may not be required.

209.219

Figure 17-1.—Format of a naval letter.

control of the dissemination of classified information. Therefore, knowledge or possession of classified information is permitted only to those who actually require it in the performance of their duties, and then only after they have been granted the appropriate security clearances. This principle is generally referred to as a "need to know," and is a prime requisite for access to classified information.

Access to classified material is not automatically granted because a person has the proper clearances, holds a particular billet, or is sufficiently senior in authority, but only if the criteria of proper clearance and "need to know" are both met.

LIMITATIONS OF SECURITY

Security is a means—not an end. Rules which govern security of classified matter are much the same as gunnery safety rules. They do not guarantee protection and they do not attempt to meet every situation.

Security regulations are not intended to restrict the initiative of mature individuals. With common sense and mature thinking, it is possible to obtain a satisfactory degree of security with a minimum of sacrifice in operating efficiency.

CLASSIFICATION CATEGORIES

Official information which requires protection in the interest of national defense is limited to one of three categories: Top Secret, Secret, or Confidential. No information may be withheld or classified, if otherwise releasable, simply because such information might reveal an error or inefficiency or might be embarrassing.

Top Secret

The use of the classification Top Secret is limited to defense information or material which requires the highest degree of protection. Top Secret is applied only to that information or material, the defense aspect of which is paramount and the unauthorized disclosure of which could result in EXCEPTIONALLY GRAVE DAMAGE to the Nation, such as the following:

1. Leading to a break in diplomatic relations, armed attack on the United States or its allies, or a war.

2. The compromise of military plans or scientific or technological developments vital to the national defense.

Secret

The use of the classification Secret is limited to defense information or material, the unauthorized disclosure of which could result in SERIOUS DAMAGE to the Nation, such as the following:

1. Jeopardizing the international relations of the United States.

2. Endangering the effectiveness of a program or policy vital to the national defense.

3. Compromising important military or defense plans, scientific or technological developments important to national defense.

4. Revealing important intelligence operations.

Confidential

Information or material classified Confidential is placed in the category whose unauthorized disclosure could cause damage to the defense interest of the Nation.

If it is desired to understand more thoroughly the various categories of classified matter, the Security Manual has a number of examples in each category. However, the most important thing to be learned at this time is that each category represents a degree of damage to the Nation that could be done by letting this material get into the hands of unauthorized persons. The category also determines how the material is handled and the measures used for its protection, as will be seen later in this chapter.

SPECIAL CATEGORIES

Theoretically, the three classifications discussed above should safeguard any information desired. However, there are several other safeguards prescribed for use. These are not security classifications, as such, but indicate an increased degree of security to be applied when handling items thus marked.

Restricted Data

Restricted Data is assigned to documents or material concerning the design, manufacture, or utilization of atomic weapons; the production of special nuclear material; or the use of special nuclear material in the production of energy, unless such data or materials have been legally removed from this category.

For Official Use Only

"For Official Use Only" is assigned to official information which requires protection in accordance with statutory requirements or in the public interest, but which is not within the purview of the rules for safeguarding information in the interest of national defense. Its description, use, and limitations are set forth in the effective edition of SECNAVINST. 5570.2.

Special Handing Required/Not Releasable To Foreign Nationals

The marking "NO FOREIGN DISSEM" may be used on documents containing information concerning (1) intelligence, and (2) crypto security, transmission security, and emission security systems used to transmit intelligence, when it has been predetermined that the data may not be released to foreign nationals or governments. The marking "NOFORN" is authorized for electrically transmitted messages and automatic data processing.

Classified intelligence documents or nonintelligence documents, even though they bear no control markings, may not be released to foreign nationals or foreign governments without prior approval of the Chief of Naval Operations. Therefore, all classified documents, whether so marked or not, are NOFORN.

Special Access Programs

"Special Access Programs" are those programs identified with specific projects or subjects requiring security protection or handling not guaranteed by the normal security classification and requiring that the program materials be handled and reviewed only by specially cleared or authorized personnel.

The administrative responsibility for any special access program rests with the command having the need for a special access program.

VIOLATIONS AND COMPROMISES

Any person having knowledge of the loss or possible compromise of classified matter must report the fact immediately to a responsible official. The official then takes the proper action as outlined in detail in chapter 6 of the regulation.

Violations of regulations pertaining to the safeguarding of classified information, but not resulting in its loss, compromise, or disclosure, are acted upon by the commanding officer.

It must always be remembered that the AG is responsible for classified material in his care. Anyone who mishandles classified material is disciplined by his commanding officer or by a court-martial, depending on the circumstances.

PERSONAL CENSORSHIP

It is quite natural for a man to be proud of the work he is doing. He wants to share this pride with his friends and family. Enthusiasm toward one's work is clearly a desirable trait, but not when it results in discussing classified information.

To maintain security one should decline to discuss official matters by skillful maneuvering of the conversation or by outright refusal to talk shop.

CUSTODY

Stowage

The first obligation of any person working with classified material is to protect that material. Top Secret, Secret, or Confidential material may neither be removed from its designated working space without approval of competent authority nor left unguarded. It is kept locked in its proper accommodation, for a single glance at a classified intelligence plan might compromise the entire plan. Another danger is that a photograph might be taken in a split second with a concealed camera.

It has been stated that the Navy's security system operates on the principle of "need to know." It is essential then, that combinations and keys to classified containers be known only to those who are actually using the material in their work. To ensure this, certain rules must be followed.

The combination or key to a security container should be changed at the time it is received, at the time of transfer of any person having knowledge of it, at anytime there is reason to believe it has been compromised, or in any case at least once every 12 months.

If a container in which classified material is stowed is found unlocked in the absence of assigned personnel, it should be reported immediately to the senior duty officer. The unlocked container must be guarded until the duty officer arrives at the scene. The duty officer then inspects the classified material involved, locks the container, and makes a security violation report to the commanding officer. Appropriate further action is taken by the commanding officer.

Accounting

Except for publications containing a distribution list by copy number, all copies of Top Secret documents must be serially numbered at the time of origination in the following manner: "Copy No.___of___copies."

A list of all persons having knowledge of a particular item of Top Secret information must be maintained and a continuous chain of receipts kept to ensure positive control. The control of Top Secret material is the duty of the Top Secret Control Officer.

CUSTODIAL PRECAUTIONS

Each individual in the Naval Establishment should take every precaution to prevent deliberate or casual access to classified information by unauthorized persons. Some of the precautions are discussed in this section.

When classified materials are removed from stowage for working purposes they should be kept face down or covered when not in use.

Visitors not authorized access to the particular classified information within a working space should be received in a specially designated visiting space.

Classified information should never be discussed over a telephone. Remember also that a telephone scrambler device does not ensure security.

If, for any reason, a room must be vacated during working hours, all classified material in the room must be locked in its proper stowage containers.

At the close of the working day a system of security checks should be carried out to ensure that the classified material is properly protected. All classified material must be properly stowed. All classified material which must be passed from watch to watch has to be properly accounted for. All burn bags should be burned or properly stowed. The contents of wastebaskets which contain classified material must be burned or stowed. All classified notes, rough drafts, and similar papers are placed in the burn bag during the day as a matter of routine.

Personnel concerned with locking combination locks or safes must remember to rotate the dial of all combination locks at least four turns in the same direction when securing them. In most locks, if the dials are given only a quick twist, it is generally possible to open the lock merely by turning the dial back in the opposite direction. Also, responsible personnel are assigned to check all drawers of safes and file cabinets to assure that they are held firmly in the locked position when secured.

In the event of a fire alarm or other emergency, classified material is stowed in the same manner as at the end of a working day. Each person who has classified material in his possession at the time of a fire alarm or other emergency assures that the material is properly safeguarded.

Other examples of handling classified material during emergencies are discussed in OPNAVINST 5510.1 (Series).

DISPOSITION OF CLASSIFIED MATERIAL

When military personnel resign or are to be separated from the Navy or released from active duty, all classified material held by them is turned in to the source from which it was received, to their commanding officer, or to the nearest naval command, as appropriate, prior to the delivery of final orders or separation papers.

Personnel to be separated from the Navy or to be released to inactive duty submit to their commanding officer a signed statement to the effect that they have turned in all classified material. Also, they are instructed that they are not to reveal classified information, of which they might have knowledge, even after discharge.

APPENDIX I

THE METRIC SYSTEM

U.S. CUSTOMARY AND METRIC SYSTEM UNITS OF MEASUREMENTS

THESE PREFIXES MAY BE APPLIED TO ALL SI UNITS

Multiples and Submultiples	Prefixes	Symbols
1 000 000 000 000 = 10^{12}	tera (tĕr'ȧ)	T
1 000 000 000 = 10^{9}	giga (jĭ'gȧ)	G
1 000 000 = 10^{6}	mega (mĕg'ȧ)	M ●
1 000 = 10^{3}	kilo (kĭl'ô)	k ●
100 = 10^{2}	hecto (hĕk'tô)	h
10 = 10	deka (dĕk'ȧ)	da
0.1 = 10^{-1}	deci (dĕs'ĭ)	d
0.01 = 10^{-2}	centi (sĕn'tĭ)	c ●
0.001 = 10^{-3}	milli (mĭl'ĭ)	m ●
0.000 001 = 10^{-6}	micro (mī'krô)	μ ●
0.000 000 001 = 10^{-9}	nano (năn'ô)	n
0.000 000 000 001 = 10^{-12}	pico (pē·kô)	p
0.000 000 000 000 001 = 10^{-15}	femto (fĕm'tô)	f
0.000 000 000 000 000 001 = 10^{-18}	atto (ăt'tô)	a

● MOST COMMONLY USED

COMMON EQUIVALENTS AND CONVERSIONS

Approximate Common Equivalents		Conversions Accurate to Parts Per Million	
1 inch	= 25 millimeters	inches x 25.4*	= millimeters
1 foot	= 0.3 meter	feet x 0.3048*	= meters
1 yard	= 0.9 meter	yards x 0.9144*	= meters
1 mile	= 1.6 kilometers	miles x 1.609 344	= kilometers
1 square inch	= 6.5 square centimeters	square inches x 6.4516*	= square centimeters
1 square foot	= 0.09 square meter	square feet x 0.092 903	= square meters
1 square yard	= 0.8 square meter	square yards x 0.836 127	= square meters
1 acre	= 0.4 hectare †	acres x 0.404 686	= hectares
1 cubic inch	= 16 cubic centimeters	cubic inches x 16.387 064	= cubic centimeters
1 cubic foot	= 0.03 cubic meter	cubic feet x 0.028 317	= cubic meters
1 cubic yard	= 0.8 cubic meter	cubic yards x 0.764 555	= cubic meters
1 quart (lq.)	= 1 liter †	quarts (lq.) x 0.946 353	= liters
1 gallon	= 0.004 cubic meter	gallons x 0.003 785	= cubic meters
1 ounce (avdp)	= 28 grams	ounces (avdp) x 28.349 523	= grams
1 pound (avdp)	= 0.45 kilogram	pounds (avdp) x 0.453 592	= kilograms
1 horsepower	= 0.75 kilowatt	horsepower x 0.745 7	= kilowatts
1 millimeter	= 0.04 inch	millimeters x 0.039 37	= inches
1 meter	= 3.3 feet	meters x 3.280 84	= feet
1 meter	= 1.1 yards	meters x 1.093 613	= yards
1 kilometer	= 0.6 mile	kilometers x 0.621 371	= miles
1 square centimeter	= 0.16 square inch	square centimeters x 0.155	= square inches
1 square meter	= 11 square feet	square meters x 10.76391	= square feet
1 square meter	= 1.2 square yards	square meters x 1.195 99	= square yards
1 hectare †	= 2.5 acres	hectares x 2.471054	= acres
1 cubic centimeter	= 0.06 cubic inch	cubic centimeters x 0.061 024	= cubic inches
1 cubic meter	= 35 cubic feet	cubic meters x 35.31467	= cubic feet
1 cubic meter	= 1.3 cubic yards	cubic meters x 1.307 951	= cubic yards
1 liter †	= 1 quart (lq.)	liters x 1.056 688	= quarts (lq.)
1 cubic meter	= 250 gallons	cubic meters x 264.172	= gallons
1 gram	= 0.035 ounces (avdp)	grams x 0.035 274	= ounces (avdp)
1 kilogram	= 2.2 pounds (avdp)	kilograms x 2.204 623	= pounds (avdp)
1 kilowatt	= 1.3 horsepower	kilowatts x 1.341 02	= horsepower

† common term not used in SI

* exact

APPENDIX II

GLOSSARY

ABSOLUTE INSTABILITY. The state of a column of air in the atmosphere when it has a superadiabatic lapse rate of temperature. An air parcel displaced vertically would be accelerated in the direction of the displacement.

ABSOLUTE STABILITY. The state of a column of air in the atmosphere when its lapse rate of temperature is less than the saturation adiabatic lapse rate. The parcel will be more dense than its environment and tend to sink back to its level of origin.

ABSORPTION. The process in which incident radiant energy is retained by a substance.

ADVECTION. The process of transporting an atmospheric property solely by the mass motion (velocity field) of the atmosphere.

ADVECTION FOG. A type of fog caused by the advection of moist air over a cold surface, and the consequent cooling of that air to below its dew point.

AIR MASS. A widespread body of air that is approximately homogeneous in its horizontal extent, with reference to temperature and moisture.

ALBEDO. The ratio of the amount of electromagnetic radiation reflected by a body to the amount incident upon it.

ALTIMETER SETTING. The pressure value to which an aircraft altimeter scale is set so it will indicate the altitude above MSL of an aircraft on the ground at the location for which the value was determined.

ANABATIC WIND. An upslope wind; usually applied only when the wind is blowing up a hill or mountain as the result of surface heating.

ANTICYCLOGENESIS. The strengthening or development of an anticyclonic circulation in the atmosphere.

ANTICYCLOLYSIS. The weakening of an anticyclonic circulation in the atmosphere.

ANTICYCLONE. A closed anticyclonic circulation in the atmosphere. Used interchangeably with high.

ANTICYCLONIC. A clockwise rotation in the Northern Hemisphere and counterclockwise in the Southern Hemisphere.

AUTOCONVECTIVE LAPSE RATE. The environmental lapse rate of temperature in an atmosphere in which the density is constant with height.

BACKING. A change in wind direction in a counterclockwise sense in the Northern Hemisphere and clockwise in the Southern Hemisphere.

BALLISTIC DENSITY. A representation of the atmospheric density actually encountered by a projectile in flight, expressed as a percentage of the density according to the standard artillery atmosphere.

BATHYTHERMOGRAPH. A device for obtaining a record of temperature against depth in the ocean.

BLACK BODY. A hypothetical body which absorbs all of the electromagnetic radiation striking it; one which neither reflects nor transmits any of the incident radiation.

BLOCKING HIGH. Any high or anticyclone that remains nearly stationary or moves slowly westward so it effectively blocks the movement of migratory cyclones across its latitudes.

BRIGHT BAND. The enhanced radar echo of snow as it melts to rain, as displayed on the RHI scope. Located approximately 1,500 feet below the 0° C isotherm.

BUYS BALLOT'S LAW. The law describing the relationship of the horizontal wind direction in the atmosphere to the pressure distribution: In the Northern Hemisphere, with your back to the wind, the lowest pressure will be on your left; in the Southern Hemisphere, the relation is reversed.

CENTER OF ACTION. Any one of the semipermanent highs and lows that appear on mean charts of sea level pressure.

CENTRAL PRESSURE. The atmospheric pressure at the center of a high or low; the highest pressure in a high, the lowest in a low.

CHINOOK. The warm dry foehn wind on the eastern side of the Rocky Mountains.

CLOSED HIGH. A high that may be completely encircled by an isobar or contour line.

CLOSED LOW. A low that may be completely encircled by an isobar or contour line.

COALESCENCE. In cloud physics, the merging of two water drops into a single larger drop.

COLD HIGH. At a given level in the atmosphere, any high that is generally characterized by colder air near its center than around its periphery.

COLD LOW. Any low that is generally characterized at a given level in the atmosphere by colder air near its center than around its periphery.

CONDITIONAL INSTABILITY. The state of a column of air in the atmosphere when its lapse rate of temperature is less than the dry adiabatic lapse rate but greater than the saturation adiabatic lapse rate.

CONDENSATION. The physical process by which a vapor becomes a liquid or solid.

CONTOUR. The term used in meteorology usually referring to a line of constant height on a constant pressure chart.

CONVECTION. Atmospheric motions that are predominantly vertical, resulting in vertical transport and mixing of atmospheric properties.

CUT-OFF HIGH. A warm high which has become displaced out of the basic westerly, and lies to the north of this current.

CUT-OFF LOW. A cold low which has become displaced out of the basic westerly, and lies to the south of this current.

CYCLOGENESIS. Any development or strengthening of cyclonic circulation in the atmosphere. The initial appearance of a low or trough, as well as the intensification of an existing cyclonic flow.

CYCLOLYSIS. Any weakening of cyclonic circulation in the atmosphere.

CYCLONIC. A counterclockwise rotation in the Northern Hemisphere and a clockwise rotation in the Southern Hemisphere.

DECIBAR. A unit of pressure used principally in oceanography.

DEEPENING. A decrease in the central pressure system. The term usually applies to a low rather than to a high.

ENTRAINMENT. The mixing of environmental air into a preexisting, organized air current so the environmental air becomes part of the current.

EVAPORATION. The physical process by which a liquid or solid is transformed to the gaseous state.

EXTRATROPICAL CYCLONE. Any cyclonic-scale storm that is not a tropical cyclone, usually referring only to the migratory frontal cyclones of middle and high latitudes.

FALL WIND. A strong, cold, downslope wind.

FILLING. An increase in the central pressure of a pressure system on a constant-height chart. Commonly applied to a low rather than to a high.

FOEHN WIND. A warm, dry wind on the lee side of a mountain range, the warmth and dryness of the air being due to adiabatic compression upon descending the mountain slopes.

FRONTOGENESIS. The initial formation of a front or frontal zone.

FRONTOLYSIS. The dissipation of a front or frontal zone.

GLACIER WIND. A shallow gravity wind along the icy surface of a glacier, caused by the temperature difference between the air in contact with the glacier and the free air at the same altitude.

HORSE LATITUDES. The belts of latitude over the oceans at approximately 30° - 35° N and S where winds are predominantly calm or very light and the weather hot and dry.

HURRICANE. A severe tropical storm in the North Atlantic, Caribbean, Gulf of Mexico, and Eastern North Pacific east of 180° longitude, whose wind speed is more than 63 knots.

INVERSION. A departure from the usual increase or decrease with altitude of the value of an atmospheric property.

ISALLOBAR. A line of equal change in atmospheric pressure during a specified time interval.

ISOHALINE. A line of equal or constant salinity.

ISOPLETH. A line of equal or constant value of a given quantity.

ISOTACH. A line on a given surface connecting points of equal wind speed.

ISOTHERM. A line of equal or constant temperature.

ISOTHERMAL. Of equal or constant temperature, with respect to space or time.

KATABATIC WIND. Any wind blowing down an incline; the opposite of anabatic.

LAND BREEZE. A coastal wind blowing from land to sea, caused by the temperature difference when the sea surface is warmer than the adjacent land. Usually occuring at night.

LAYER DEPTH. The thickness of the mixed layer; or the depth to the top of the thermocline.

LOOMING. A mirage effect produced by greater-than-normal refraction in the lower atmosphere, thus permitting objects to be seen that are usually below the horizon.

MACKEREL SKY. A sky with considerable cirrocumulus or small-element altocumulus clouds, resembling the scales on a mackerel; clouds of the variety vertebratus.

MERIDIONAL FLOW. A type of atmospheric circulation pattern in which the meridional (north and south) component of motion is unusually pronounced.

MIRAGE. A refraction phenomenon wherein an image of some object is made to appear displaced from its true position.

MIXED LAYER. The surface layer of virtually isothermal water.

MONSOON. The name for seasonal winds caused primarily by the much greater annual variation of temperature over large land areas compared with the neighboring ocean surfaces, causing an excess of pressure over the continents in winter and a deficit in summer.

MOUNTAIN WIND. The wind that descends a mountain valley at night; a katabatic wind.

OROGRAPHIC LIFTING. The lifting of an air current caused by its passage up and over a mountain.

POLAR FRONT. The semipermanent, semicontinuous front separating air masses of tropical and polar origin. This is the major front in terms of air mass contrast and susceptibility to cyclonic disturbance.

POTENTIAL TEMPERATURE. The temperature a parcel of dry air would have if brought adiabatically from its initial state to the standard pressure of 1000 mb.

PRESSURE GRADIENT. The rate of decrease (gradient) of pressure in space at a fixed time.

RADIATION FOG. A major type of fog, produced over a land area when radiational cooling reduces the temperature to or below its dew point.

SEA BREEZE. A coastal wind that blows from sea to land, caused by the temperature difference when the sea surface is colder than the adjacent land. Usually a daytime occurrence.

SHEAR LINE. A line or narrow zone across which there is an abrupt change in horizontal wind component parallel to this line; a line of maximum horizontal wind shear.

SUBLIMATION. The transition of a substance from the solid state directly to the vapor state, or vice versa, without passing through an intermediate liquid state.

SUBSIDENCE. A descending motion of air in the atmosphere, usually with the implication that the condition extends over a rather broad area.

SUBSIDENCE INVERSION. A temperature inversion produced by the adiabatic warming of a layer of subsiding air.

THERMAL HIGH. A high resulting from the cooling of air by a cold underlying surface, and remaining nearly stationary over the cold surface.

THERMAL LOW. An area of low pressure due to high temperatures caused by intensive heating at the earth's surface. They are nonfrontal, their circulation generally weak and diffuse, and they remain stationary over the area that produced them.

TRADE WINDS. The wind system, occupying most of the tropics, which blows from the subtropical highs toward the equatorial trough; a major component of the general circulation of the atmosphere. The winds are northeasterly in the Northern Hemisphere and southeasterly in the Southern Hemisphere.

TROUGH. An elongated area of relatively low pressure.

UPSLOPE FOG. A type of fog formed when air flows upward over rising terrain and adiabatically cooled to or below its dewpoint.

UPSTREAM. In the direction from which the wind or system is flowing.

UPWELLING. The rising of water toward the surface from subsurface layers of a body of water.

VALLEY WIND. A wind which ascends a mountain valley during the day.

VEERING. A change in wind direction in a clockwise manner.

ZONAL WIND. The wind, or wind component, along the local parallel of latitude. The latitudinal (east or west) component of existing flow.

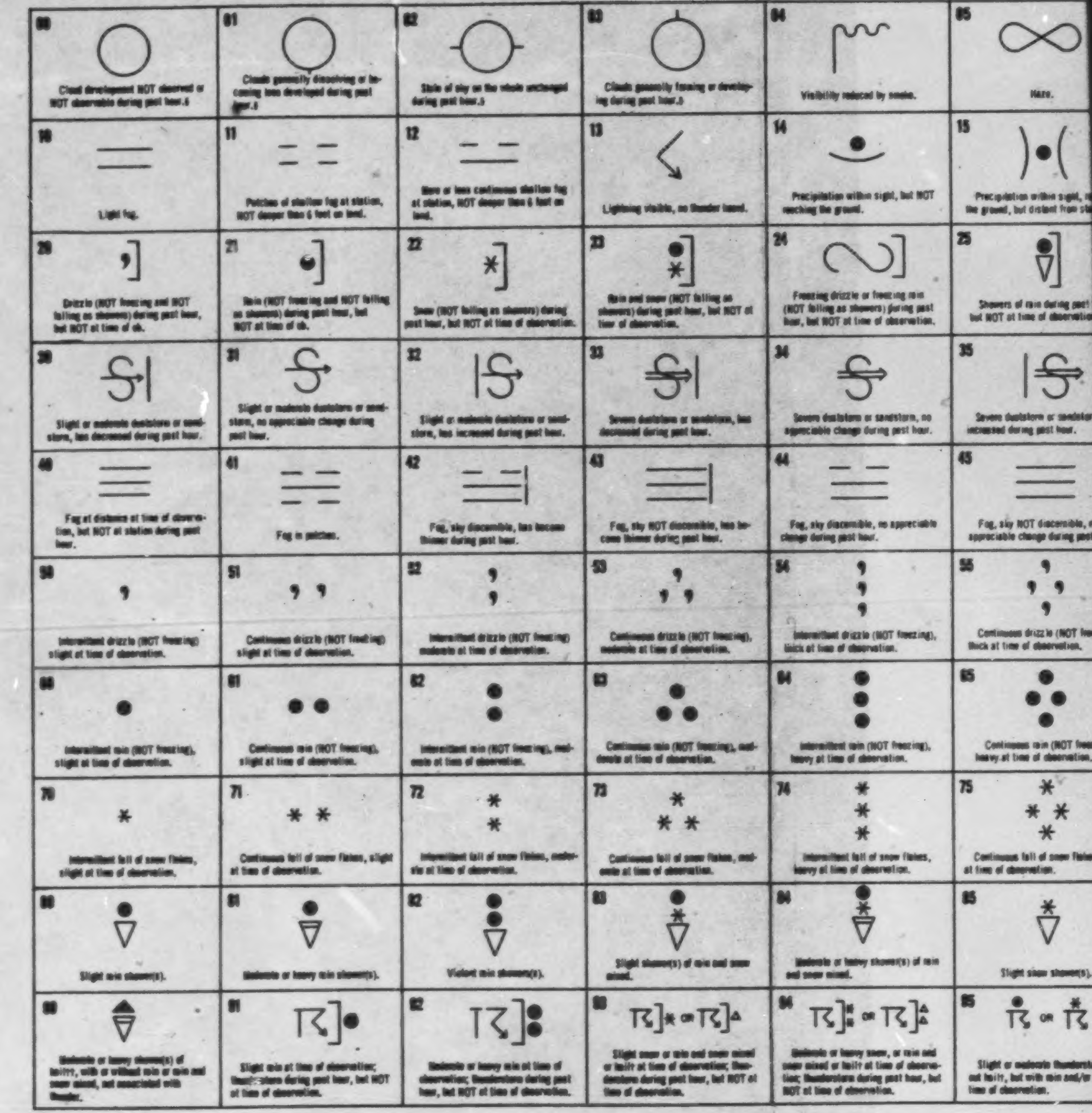
APPENDIX III

EXPLANATION OF WEATHER CODE FIGURES AND SYMBOLS

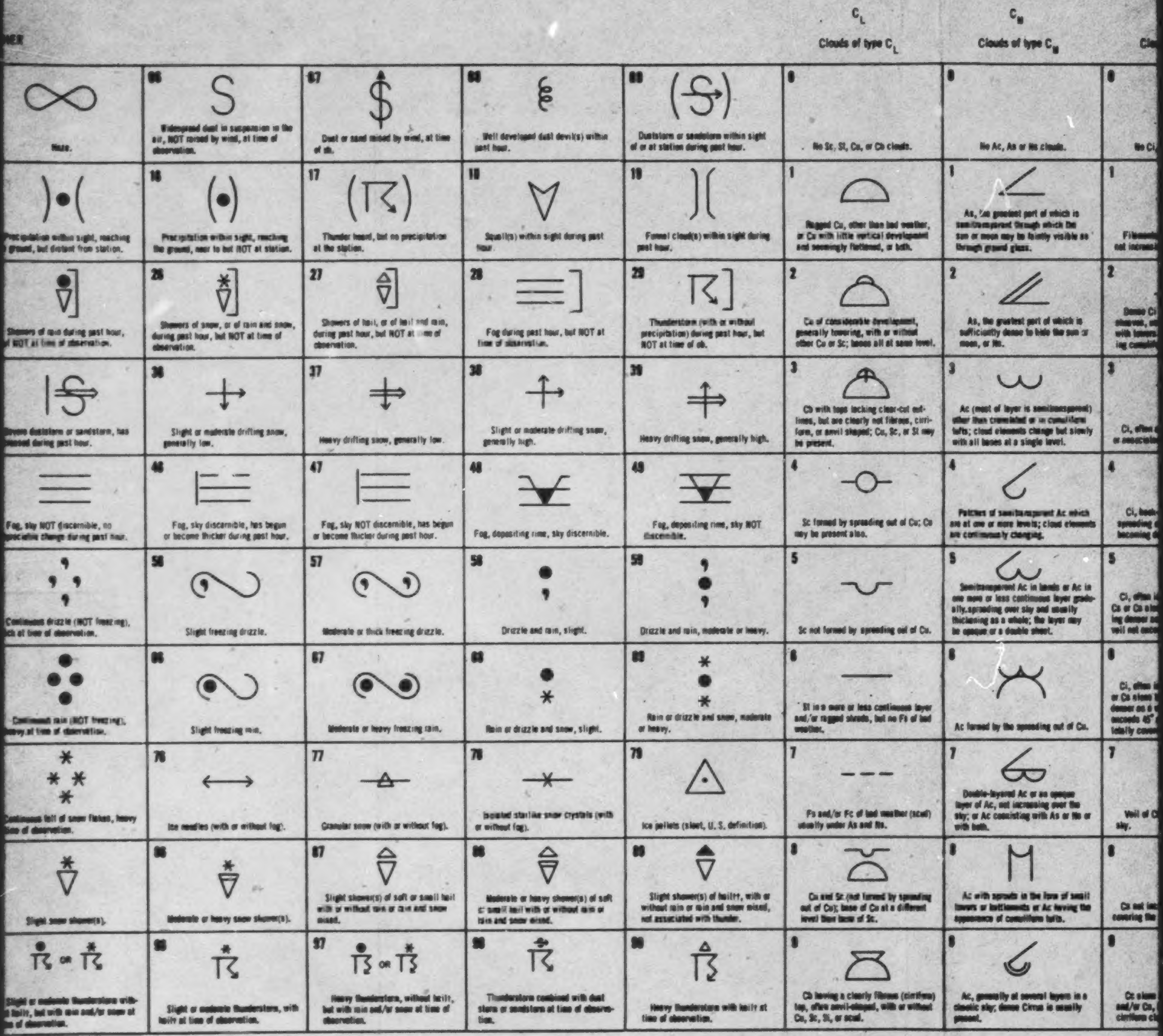
§ The symbol is not plotted for "ww" when "00" is reported. When "01, 02, or 03" is reported for "ww", the symbol is plotted as the station circle.
† Refers to "hail" only. †† Refers to "Soft hail", "small hail", and "hail".

ww

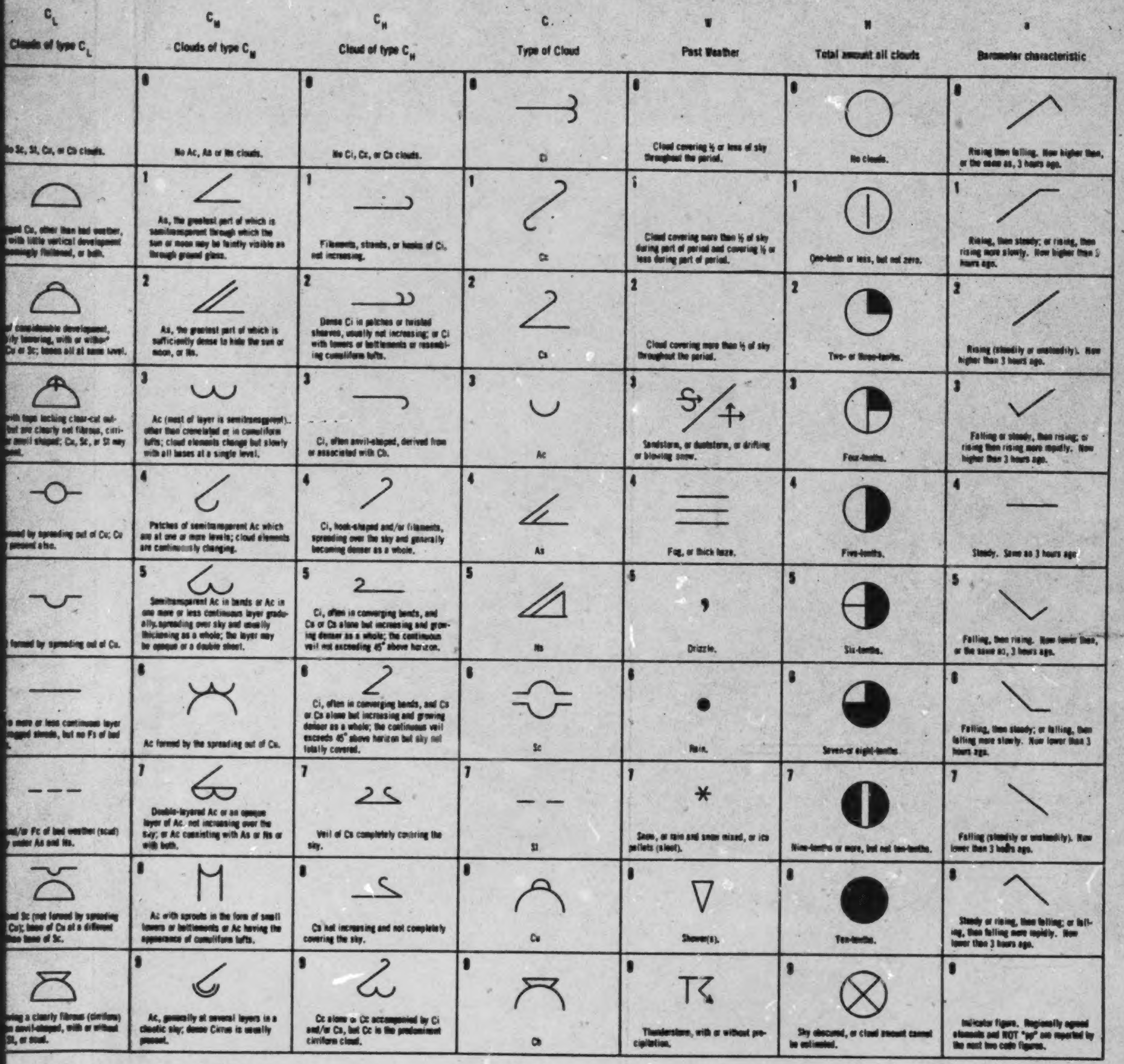
PRESENT WEATHER



00 Cloud development NOT observed or NOT observable during past hour.§	01 Clouds generally dissolving or becoming less developed during past hour.§	02 State of sky on the whole unchanged during past hour.§	03 Clouds generally forming or developing during past hour.§	04 Visibility reduced by smoke.	05 Haze.
10 Light fog.	11 Patches of shallow fog at station, NOT deeper than 6 feet on land.	12 More or less continuous shallow fog at station, NOT deeper than 6 feet on land.	13 Lightning visible, no thunder heard.	14 Precipitation within sight, but NOT reaching the ground.	15 Precipitation within sight, r the ground, but distant from st
20 Drizzle (NOT freezing and NOT falling as showers) during past hour, but NOT at time of ob.	21 Rain (NOT freezing and NOT falling as showers) during past hour, but NOT at time of ob.	22 Snow (NOT falling as showers) during past hour, but NOT at time of observation.	23 Rain and snow (NOT falling as showers) during past hour, but NOT at time of observation.	24 Freezing drizzle or freezing rain (NOT falling as showers) during past hour, but NOT at time of observation.	25 Showers of rain during past but NOT at time of observatio
30 Slight or moderate duststorm or sandstorm, has decreased during past hour.	31 Slight or moderate duststorm or sandstorm, no appreciable change during past hour.	32 Slight or moderate duststorm or sandstorm, has increased during past hour.	33 Severe duststorm or sandstorm, has decreased during past hour.	34 Severe duststorm or sandstorm, no appreciable change during past hour.	35 Severe duststorm or sandstor increased during past hour.
40 Fog at distance at time of observation, but NOT at station during past hour.	41 Fog in patches.	42 Fog, sky discernible, has become thinner during past hour.	43 Fog, sky NOT discernible, has become thinner during past hour.	44 Fog, sky discernible, no appreciable change during past hour.	45 Fog, sky NOT discernible, no appreciable change during past
50 Intermittent drizzle (NOT freezing) slight at time of observation.	51 Continuous drizzle (NOT freezing) slight at time of observation.	52 Intermittent drizzle (NOT freezing) moderate at time of observation.	53 Continuous drizzle (NOT freezing), moderate at time of observation.	54 Intermittent drizzle (NOT freezing), thick at time of observation.	55 Continuous drizzle (NOT free thick at time of observation.
60 Intermittent rain (NOT freezing), slight at time of observation.	61 Continuous rain (NOT freezing), slight at time of observation.	62 Intermittent rain (NOT freezing), moderate at time of observation.	63 Continuous rain (NOT freezing), moderate at time of observation.	64 Intermittent rain (NOT freezing), heavy at time of observation.	65 Continuous rain (NOT freezin heavy at time of observation.
70 Intermittent fall of snow flakes, slight at time of observation.	71 Continuous fall of snow flakes, slight at time of observation.	72 Intermittent fall of snow flakes, moderate at time of observation.	73 Continuous fall of snow flakes, moderate at time of observation.	74 Intermittent fall of snow flakes, heavy at time of observation.	75 Continuous fall of snow flakes, at time of observation.
80 Slight rain shower(s).	81 Moderate or heavy rain shower(s).	82 Violent rain shower(s).	83 Slight shower(s) of rain and snow mixed.	84 Moderate or heavy shower(s) of rain and snow mixed.	85 Slight snow shower(s).
90 Moderate or heavy shower(s) of hail††, with or without rain or rain and snow mixed, not associated with thunder.	91 Slight rain at time of observation; thunderstorm during past hour, but NOT at time of observation.	92 Moderate or heavy rain at time of observation; thunderstorm during past hour, but NOT at time of observation.	93 Slight snow or rain and snow mixed or hail† at time of observation; thunderstorm during past hour, but NOT at time of observation.	94 Moderate or heavy snow, or rain and snow mixed or hail† at time of observation; thunderstorm during past hour, but NOT at time of observation.	95 Slight or moderate thunderstorm w out hail, but with rain and/or sno time of observation.



NER					C_L Clouds of type C_L	C_M Clouds of type C_M	Cl
Haze.	06 Widespread dust in suspension in the air, NOT raised by wind, at time of observation.	07 Dust or sand raised by wind, at time of ob.	08 Well developed dust devil(s) within past hour.	09 Duststorm or sandstorm within sight of or at station during past hour.	0 No Sc, St, Cu, or Cb clouds.	0 No Ac, As or Ns clouds.	0 No Ci
recipitation within sight, reaching ground, but distant from station.	16 Precipitation within sight, reaching the ground, near to but NOT at station.	17 Thunder heard, but no precipitation at the station.	18 Squall(s) within sight during past hour.	19 Funnel cloud(s) within sight during past hour.	1 Ragged Cu, other than bad weather, or Cu with little vertical development and seemingly flattened, or both.	1 As, the greatest part of which is semitransparent through which the sun or moon may be faintly visible as through ground glass.	1 Filame not increa
Showers of rain during past hour, NOT at time of observation.	26 Showers of snow, or of rain and snow, during past hour, but NOT at time of observation.	27 Showers of hail, or of hail and rain, during past hour, but NOT at time of observation.	28 Fog during past hour, but NOT at time of observation.	29 Thunderstorm (with or without precipitation) during past hour, but NOT at time of ob.	2 Cu of considerable development, generally towering, with or without other Cu or Sc; bases all at same level.	2 As, the greatest part of which is sufficiently dense to hide the sun or moon, or Ns.	2 Dense Ci sheaves, with towers ing cumuli
evere duststorm or sandstorm, has eased during past hour.	36 Slight or moderate drifting snow, generally low.	37 Heavy drifting snow, generally low.	38 Slight or moderate drifting snow, generally high.	39 Heavy drifting snow, generally high.	3 Cb with tops lacking clear-cut outlines, but are clearly not fibrous, cirriform, or anvil shaped; Cu, Sc, or St may be present.	3 Ac (most of layer is semitransparent) other than crenelated or in cumuliform tufts; cloud elements change but slowly with all bases at a single level.	3 Ci, often or associate
Fog, sky NOT discernible, no preciable change during past hour.	46 Fog, sky discernible, has begun or become thicker during past hour.	47 Fog, sky NOT discernible, has begun or become thicker during past hour.	48 Fog, depositing rime, sky discernible.	49 Fog, depositing rime, sky NOT discernible.	4 Sc formed by spreading out of Cu; Cu may be present also.	4 Patches of semitransparent Ac which are at one or more levels; cloud elements are continuously changing.	4 Ci, hook- spreading becoming d
Continuous drizzle (NOT freezing), ck at time of observation.	56 Slight freezing drizzle.	57 Moderate or thick freezing drizzle.	58 Drizzle and rain, slight.	59 Drizzle and rain, moderate or heavy.	5 Sc not formed by spreading out of Cu.	5 Semitransparent Ac in bands or Ac in one more or less continuous layer gradually spreading over sky and usually thickening as a whole; the layer may be opaque or a double sheet.	5 Ci, often Cs or Cs alo ing denser a veil not exce
Continuous rain (NOT freezing), avy at time of observation.	66 Slight freezing rain.	67 Moderate or heavy freezing rain.	68 Rain or drizzle and snow, slight.	69 Rain or drizzle and snow, moderate or heavy.	6 St in a more or less continuous layer and/or ragged shreds, but no Fs of bad weather.	6 Ac formed by the spreading out of Cu.	6 Ci, often or Cs alone denser as a exceeds 45° totally cove
Continuous fall of snow flakes, heavy ime of observation.	76 Ice needles (with or without fog).	77 Granular snow (with or without fog).	78 Isolated starlike snow crystals (with or without fog).	79 Ice pellets (sleet, U. S. definition).	7 Fs and/or Fc of bad weather (scud) usually under As and Ns.	7 Double-layered Ac or an opaque layer of Ac, not increasing over the sky; or Ac coexisting with As or Ns or with both.	7 Veil of C sky.
Slight snow shower(s).	86 Moderate or heavy snow shower(s).	87 Slight shower(s) of soft or small hail with or without rain or rain and snow mixed.	88 Moderate or heavy shower(s) of soft or small hail with or without rain or rain and snow mixed.	89 Slight shower(s) of hail†, with or without rain or rain and snow mixed, not associated with thunder.	8 Cu and Sc (not formed by spreading out of Cu); base of Cu at a different level than base of Sc.	8 Ac with sprouts in the form of small towers or battlements or Ac having the appearance of cumuliform tufts.	8 Cs not inc covering the
Slight or moderate thunderstorm with- t hail, but with rain and/or snow at e of observation.	96 Slight or moderate thunderstorm, with hail† at time of observation.	97 Heavy thunderstorm, without hail†, but with rain and/or snow at time of observation.	98 Thunderstorm combined with dust storm or sandstorm at time of observation.	99 Heavy thunderstorm with hail† at time of observation.	9 Cb having a clearly fibrous (cirriform) top, often anvil-shaped, with or without Cu, Sc, St, or scud.	9 Ac, generally at several layers in a chaotic sky; dense Cirrus is usually present.	9 Cc alone and/or Cs, cirriform cl



C_L Clouds of type C_L	C_M Clouds of type C_M	C_H Cloud of type C_H	C Type of Cloud	W Past Weather	N Total amount all clouds	a Barometer characteristic
o Sc, St, Cu, or Cb clouds.	0 No Ac, As or Ns clouds.	0 No Ci, Cc, or Cs clouds.	0 Ci	0 Cloud covering ½ or less of sky throughout the period.	0 No clouds.	0 Rising then falling. Now higher than, or the same as, 3 hours ago.
ed Cu, other than bad weather, with little vertical development emingly flattened, or both.	1 As, the greatest part of which is semitransparent through which the sun or moon may be faintly visible as through ground glass.	1 Filaments, strands, or hooks of Ci, not increasing.	1 Cc	1 Cloud covering more than ½ of sky during part of period and covering ½ or less during part of period.	1 One-tenth or less, but not zero.	1 Rising, then steady; or rising, then rising more slowly. Now higher than 3 hours ago.
f considerable development, ly towering, with or without Cu or Sc; bases all at same level.	2 As, the greatest part of which is sufficiently dense to hide the sun or moon, or Ns.	2 Dense Ci in patches or twisted sheaves, usually not increasing; or Ci with towers or battlements or resembling cumuliform tufts.	2 Cs	2 Cloud covering more than ½ of sky throughout the period.	2 Two- or three-tenths.	2 Rising (steadily or unsteadily). Now higher than 3 hours ago.
with tops lacking clear-cut out- but are clearly not fibrous, cirri- r anvil shaped; Cu, Sc, or St may ent.	3 Ac (most of layer is semitransparent) other than crenelated or in cumuliform tufts; cloud elements change but slowly with all bases at a single level.	3 Ci, often anvil-shaped, derived from or associated with Cb.	3 Ac	3 Sandstorm, or duststorm, or drifting or blowing snow.	3 Four-tenths.	3 Falling or steady, then rising; or rising then rising more rapidly. Now higher than 3 hours ago.
ed by spreading out of Cu; Cu present also.	4 Patches of semitransparent Ac which are at one or more levels; cloud elements are continuously changing.	4 Ci, hook-shaped and/or filaments, spreading over the sky and generally becoming denser as a whole.	4 As	4 Fog, or thick haze.	4 Five-tenths.	4 Steady. Same as 3 hours ago.
formed by spreading out of Cu.	5 Semitransparent Ac in bands or Ac in one more or less continuous layer gradually spreading over sky and usually thickening as a whole; the layer may be opaque or a double sheet.	5 Ci, often in converging bands, and Cs or Cs alone but increasing and growing denser as a whole; the continuous veil not exceeding 45° above horizon.	5 Ns	5 Drizzle.	5 Six-tenths.	5 Falling, then rising. Now lower than, or the same as, 3 hours ago.
o more or less continuous layer agged shreds, but no Fs of bad	6 Ac formed by the spreading out of Cu.	6 Ci, often in converging bands, and Cs or Cs alone but increasing and growing denser as a whole; the continuous veil exceeds 45° above horizon but sky not totally covered.	6 Sc	6 Rain.	6 Seven-or eight-tenths.	6 Falling, then steady; or falling, then falling more slowly. Now lower than 3 hours ago.
d/or Fc of bad weather (scud) under As and Ns.	7 Double-layered Ac or an opaque layer of Ac. not increasing over the sky; or Ac coexisting with As or Ns or with both.	7 Veil of Cs completely covering the sky.	7 St	7 Snow, or rain and snow mixed, or ice pellets (sleet).	7 Nine-tenths or more, but not ten-tenths.	7 Falling (steadily or unsteadily). Now lower than 3 hours ago.
d Sc (not formed by spreading Cu); base of Cu at a different han base of Sc.	8 Ac with sprouts in the form of small towers or battlements or Ac having the appearance of cumuliform tufts.	8 Cs not increasing and not completely covering the sky.	8 Cu	8 Shower(s).	8 Ten-tenths.	8 Steady or rising, then falling; or falling, then falling more rapidly. Now lower than 3 hours ago.
ing a clearly fibrous (cirriform) n anvil-shaped, with or without St, or scud.	9 Ac, generally at several layers in a chaotic sky; dense Cirrus is usually present.	9 Cc alone or Cc accompanied by Ci and/or Cs, but Cc is the predominant cirriform cloud.	9 Cb	9 Thunderstorm, with or without precipitation.	9 Sky obscured, or cloud amount cannot be estimated.	9 Indicator figure. Regionally agreed elements and NOT "pp" are reported by the next two code figures.

APPENDIX IV

FEDERAL METEOROLOGICAL FORM 1-10 SURFACE WEATHER OBSERVATIONS (NWSC 3140/7)

NWSC 3140/7 (REV. 10-74) S/N 0108-LF-031-4036

FEDERAL METEOROLOGICAL FORM 1–10 SURFACE WEATHER OBSERVATIONS

(ABRIDGED FOR NAVAL WEATHER SERVICE USE)

SUNRISE

SUNSET

STATION ELEVATION (H_p) Feet (MSL)

TIM

TYPE (1)	TIME *(LST)* (2)	SKY AND CEILING *(HUNDREDS OF FEET)* (3)	VISIBILITY (STATUTE MILES)		WEATHER AND OBSTRUCTIONS TO VISION (5)	SEA LEVEL PRES *(mb)* (6)	TEMP *(°F)* (7)	DEW-POINT *(°F)* (8)	WIND			ALSTG *(inches)* (12)	*DESIRED ORDER OF* *bases and tops, remarks* *runway conditions, weat*
			SURFACE (4)	TOWER (4a)					DIREC-TION (9)	SPEED *(knots)* (10)	CHAR-ACTER (11)		

REMARKS, NOTES, AND MISCELLANEOUS PHENOMENA (80)

TATION ELEVATION (H_p) Feet (MSL)	TIME CONVERSION *(LST to* + *Hrs* *GMT)* – *Hrs*	MAG TO TRUE + *Deg* – *Deg*	DAY	MONTH	YEAR 19	STATION NUMBER, NAME, AND STATE OR COUNTRY

ALSTG *(inches)* (12)	REMARKS AND SUPPLEMENTARY CODED DATA *DESIRED ORDER OF ENTRY: RVV, SFC based obsc phenomena, visibility, wind shifts, radar reports of bases and tops, remarks elaborating on preceding coded data. 3– and 6–hourly additive data, radiosonde data, runway conditions, weather modification, PIREPS.)* (13)	OBS INIT (15)	STATION PRESSURE *(inches)* (17)	SKY COVER TOTAL (21)	SKY COVER TOTAL OPAQUE (36)	PRECIP THUNDER-STORM AND OBSTR TO VISION (82/86)	BEGAN (83)	ENDED (84)

SUMMARY OF DAY
(MID – MID)

24-HR MAX TEMP (°F) (66)	24-HR MIN TEMP (°F) (67)

PRECIP *(inches)* (68)	SNOWFALL *(inches)* (69)	SNOW DEPTH *(inches)* (70)

PEAK GUSTS

SPEED *(knots)* (71)	DIRECTION *(true)* (72)	TIME *(LST)* (73)

SYNOPTIC SUMMARY

TIME *(LST)* (42)	NO. (43)	PRECIP *(inches)* (44)	SNOWFALL *(inches)* (45)	SNOW DEPTH *(inches)* (46)	MAX TEMP (°F) (47)	MIN TEMP (°F) (48)
Mid to	☒			☒		
	(1)					
	(2)					
	(3)					
	(4)					
Mid	☒					

B08464

APPENDIX V

SURFACE WEATHER OBSERVATIONS (SHIP) FORM (NWSC 3140/8)

DE
SURFA

NWSC FORM 3140/8 (1-68)
PREVIOUS VERSIONS OBSOLETE

U.S.S.

POSITION QLLIII	COURSE	SPD	TYPE	TIME (GMT)	SKY AND CEILING (HUNDREDS OF FEET)	VISIBILITY (NAUT. MILES)	WEATHER AND OBSTRUCTIONS TO VISION	SEA LEVEL PRESS (MBS)	TEMP (1/10°F)	DEW PT. (°F)	DIREC TION
1	2	3	4	5	6	7	8	9	10	11	12

SHIP	$99L_aL_aL_a$	$Q_cL_oL_oL_oL_o$	$YYGGi_w$	Nddff	VVwwW	PPPTT	N_hC_L
25	26	27	28	29	30	31	3
SHIP	99		00				
SHIP	99		03				
SHIP	99		06				
SHIP	99		09				
SHIP	99		12				
SHIP	99		15				
SHIP	99		18				
SHIP	99		21				

REMARKS, NOTES AND MISCELLANEOUS PHENOMENA

44 SUNRISE SUNSET

WEA

TYPE
45

DEPARTMENT OF THE NAVY
SURFACE WEATHER OBSERVATIONS
(SHIP)

WBAN 11

									DATE							
EATHER AND TRUCTIONS VISION	SEA LEVEL PRESS (MBS)	TEMP ($\frac{1}{10}$°F)	DEW PT. (°F)	WIND			ALTIMETER SET. (INS.)	REMARKS AND SUPPLEMENTAL CODED DATA	TOTAL SKY COVER	TOTAL OPAQUE SKY COVER	WET BULB ($\frac{1}{10}$°F)	SEA WATER ($\frac{1}{10}$°C)	SEA WAVES PERIOD HEIGHT	SWELL WAVES DIRECTION PERIOD HEIGHT	STATION PRESSURE (INS.)	OBSERVERS INITIALS
				DIRECTION	SPEED (KTS)	CHARACTER AND SHIFTS										
8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

VVwwW	PPPTT	$N_hC_LhC_MC_H$	D_sv_sapp	$0T_sT_sT_dT_d$	$1T_wT_wT_wt_T$	$2I_sE_sE_sR_s$	$3P_wP_wH_wH_w$	$d_wd_wP_wH_wH_w$	ICE	c_2KD_Ire	TEMP. ($\frac{1}{10}$°C)		
											DRY	WET	ICE
30	31	32	33	34	35	36	37	38	39	40	41	42	43
				0	1	2	3		ICE				
				0	1	2	3		ICE				
				0	1	2	3		ICE				
				0	1	2	3		ICE				
				0	1	2	3		ICE				
				0	1	2	3		ICE				
				0	1	2	3		ICE				
				0	1	2	3		ICE				

Check if ice on wet bulb

A

WEATHER AND OBSTRUCTIONS TO VISION

TYPE	BEGAN			ENDED		
	TIME	LAT.	LONG.	TIME	LAT.	LONG.
45	46	47	48	49	50	51

SUMMARY OF DAY (MIDNIGHT TO MIDNIGHT GMT)

	TIME		POSITION		WINDS		PRESSURE
	(GMT)		LATITUDE	LONGITUDE	DIRECTION	SPEED	MB
	52		53	54	55	56	57
LOWEST PRESSURE							
MAXIMUM WIND							
GALES = 34 KTS (22 KTS IF 0° TO 30° N/S)	BEGINNING	ENDING					

C-13190

APPENDIX VI

WIND WAVE/WIND SPEED TABLE

WIND WAVE/WIND SPEED TABLE

WIND SPEED		SEAMAN'S TERM	WORLD METEORO-LOGICAL ORGANI-ZATION (1964)	ESTIMATING WIND SPEED		WORLD METEOROLOGICAL ORGANIZATION		
KNOTS	KM PER HOUR			EFFECTS OBSERVED AT SEA	EFFECTS OBSERVED ON LAND	TERM	CODE	HEIGHT OF WAVES IN FEET
under 1	under 1	Calm	Calm	Sea like mirror.	Calm; smoke rises vertically.	Calm, glassy	0	0
1-3	1-5	Light air	Light air	Ripples with appearance of scales; no foam crests.	Smoke drift indicates wind direction; vanes do not move.			
4-6	6-11	Light breeze	Light breeze	Small wavelets; crests of glassy appearance, not breaking.	Wind felt on face; leaves rustle; vanes begin to move.	Calm, rippled	1	0 - 1/3
7-10	12-19	Gentle breeze	Gentle breeze	Large wavelets; crests begin to break; scattered whitecaps.	Leaves, small twigs in constant motion; light flags extended.	Smooth, wavelets	2	1/3 - 1 2/3
11-16	20-28	Moderate breeze	Moderate breeze	Small waves, becoming longer; numerous whitecaps.	Dust, leaves, and loose paper raised up; small branches move.	Slight	3	2 - 4
17-21	29-38	Fresh breeze	Fresh breeze	Moderate waves, taking longer form; many whitecaps; some spray.	Small trees in leaf begin to sway.	Moderate	4	4 - 8
22-27	39-49	Strong breeze	Strong breeze	Larger waves forming; whitecaps everywhere; more spray.	Larger branches of trees in motion; whistling heard in wires.	Rough	5	8 - 13
28-33	50-61	Moderate gale	Near gale	Sea heaps up; white foam from breaking waves begins to be blown in streaks.	Whole trees in motion; resistance felt in walking against wind.	Very rough	6	13 - 20
34-40	62-74	Fresh gale	Gale	Moderately high waves of greater length; edges of crests begin to break into spindrift; foam is blown in well-marked streaks.	Twigs and small branches broken off trees; progress generally impeded.			
41-47	75-88	Strong gale	Strong gale	High waves; sea begins to roll; dense streaks of foam; spray may reduce visibility.	Slight structural damage occurs; slate blown from roofs.			
48-55	89-102	Whole gale	Storm	Very high waves with overhanging crests; sea takes white appearance as foam is blown in very dense streaks; rolling is heavy and visibility reduced.	Seldom experienced on land; trees broken or uprooted; considerable structural damage occurs.	High	7	20 - 30
56-63	103-117	Storm	Violent storm	Exceptionally high waves; sea covered with white foam patches; visibility still more reduced.	Very rarely experienced on land; usually accompanied by widespread damage.	Very high	8	30 - 45
64-71 72-80 81-89 90-99 100-108 109-118	118-133 134-149 150-166 167-183 184-201 202-220	Hurricane	Hurricane	Air filled with foam; sea completely white with driving spray; visibility greatly reduced.		Phenomenal	9	over 45

APPENDIX VII

AERIAL METEOROLOGICAL RECONNAISSANCE REPORTING CODE

(RECCO CODE OPNAV 3140-2)

461

OPNAV FORM 3140-2 (Rev. 1-64)
(Effective January 1, 1964)

RECCO CO

(Aerial Meteorological Reconnaissanc

Section 1 — MANDATORY

								In tens, units, and tenths of degrees									In Whole Degrees Celsius									Ascending Order						
	Group			Time (GCT) of Observation (hours and minutes)	Humidity Indicator	Day of Week	Octant of Globe	Latitude	Longitude	Turbulence	Flight Conditions	True Altitude of Aircraft (100s of ft. or decameters above m. s. l.)	Type of Wind at Flight Altitude	Reliability of Wind at Flight Altitude	Wind Direction at Altitude "hhh" (10s of degrees, true)	Wind Speed at Altitude "hhh" (knots)	Temperature	Dew Point	Present Weather	Remarks on Present Weather	Index pertaining to HHH	Altitude and Other Data	Group Indicator	Total Number of Cloud Layers Reported	Cloud Amount (1st. layer)	Cloud Amount (2nd. layer)	Cloud Amount (3rd. layer)	Cloud Type	Altitude of Base of Cloud Type Reported by C	Altitude of Top of Cloud Type Reported by C	Cloud Type	Altitu
	9	xxx	9	GGgg	i_w	Y	Q	$L_aL_aL_a$	$L_oL_oL_o$	B	f_c	hhh	d_t	d_a	dd	fff	TT	T_dT_d	w	m	j	HHH	I	k_n	N_1	N_2	N_3	C	hh	HH	C	hh
SEE TABLE	1				2	3	4			5	6		7	8					9	10	11				12			13	14		13	1

SEE NOTE	8	9	9	10	10	11	12	13	14	15	15	16	17	18	19	20	21	22	23–25	23–

Sounding Data ____

TABLE 1: 9xxx9

91119	Altitude in feet	RECCO Report without RADAR Data
92229	Altitude in meters	
93339	Pressure (mbs.)	
94449	Not assigned	
95559	Not assigned	
96669	Altitude in feet	RECCO Report with RADAR Data
97779	Altitude in meters	
98889	Pressure (mbs.)	
99999	Not assigned	

TABLE 2: i_u

0	°C., No humidity report
1	°C., Relative humidity
2	°C., Diff. between dry bulb and wet bulb temp.
3	°C., Diff. between dry bulb and dew point temp.
4	°C., Dew point

TABLE 3: Y

1	Sunday
2	Monday
3	Tuesday
4	Wednesday
5	Thursday
6	Friday
7	Saturday

TABLE 4: Q

0	0° - 90°W	North Latitude
1	90° - 180°W	
2	180° - 90°E	
3	90° - 0°E	
4		
5	0° - 90°W	South Latitude
6	90° - 180°W	
7	180° - 90°E	
8	90° - 0°E	

TABLE 5: B

0	None
1	Light turbulence
2	Mod. tur. in clear air, infrequent
3	Mod. tur. in clear air, frequent
4	Mod. tur. in cloud, infrequent
5	Mod. tur. in cloud, frequent
6	Severe tur. in clear air, infrequent
7	Severe tur. in clear air, frequent
8	Severe tur. in cloud, infrequent
9	Severe tur. in cloud, frequent

TABLE 6:

0	Total amount of cloud less than
1	Total cloud amount at least 1/8, above or 1/8 - 4/8 below, or
2	Cloud amount more than 4/8 ab
3	Cloud amount 0 - 4/8 above and
4	Cloud amount more than 4/8 ab
5	Chaotic sky - many undefined la
6	In and out of clouds, on instrum
7	In and out of clouds, on instrum
8	In and out of clouds, on instrum
9	In clouds all of the time, contin
/	Impossible to determine due to

TABLE 9: w

0	Clear (no cloud at any level)
1	Partly cloudy (scattered or broken)
2	Continuous layer(s) of cloud(s)
3	Sandstorm, duststorm, or storm of drifting snow
4	Fog, thick dust, or haze
5	Drizzle
6	Rain
7	Snow or rain and snow mixed
8	Shower(s)
9	Thunderstorm(s)

TABLE 10: m

0	Light intermittent
1	Light continuous
2	Moderate intermittent
3	Moderate continuous
4	Heavy, intermittent
5	Heavy continuous
6	With rain
7	With snow
8	With hail
9	No remarks

TABLE 11: j

0	Surface pressure in whole millibars, thousands figure omitted
1	Altitude of 1,000 mb surface in geopotential meters; if negative add 500
2	Altitude of 850 mb surface in geopotential meters; if negative add 500
3	Altitude of 700 mb surface in geopotential meters
4	Altitude of 500 mb surface in geopotential decameters
5	Altitude of 300 mb surface in geopotential decameters
6	Altitude of 200 mb surface in geopotential decameters
7	Altitude of 100 mb surface in geopotential decameters
8	True altitude (radio altimeter or other method) minus pressure altitude (set at 1,013 mb) in tens of feet; if negative add 500 to absolute value (e.g. -- (minus) 100 is reported as 600)
9	Altimeter sub-scale reading in whole millibars, thousands figure omitted

TABLE 12: N_1, N_2, N_3

0	Zero	Zero
1	1/10 or less, but not zero	Okta or less but not zero
2	2/10 and 3/10	2 Oktas
3	4/10	3 Oktas
4	5/10	4 Oktas
5	6/10	5 Oktas
6	7/10 and 8/10	6 Oktas
7	9/10 or more, but not 10/10	7 Oktas or more, but not 8 Oktas
8	10/10	8 Oktas
9	Sky obscured, or cloud amount cannot be estimated	

TABLE 16: F

0	Calm
1	1 - 3 knots
2	4 - 6 knots
3	7 - 10 knots
4	11 - 16 knots
5	17 - 21 knots
6	22 - 27 knots
7	28 - 33 knots
8	34 - 40 knots
9	41 - 47 knots or over*

* See Note 20

TABLE 17: S

0	Calm (glassy)	
1	Calm (rippled)	(0 - 1 ft.)
2	Smooth (wavelets)	(1 - 2 ft.)
3	Slight	(2 - 4 ft.)
4	Moderate	(4 - 8 ft.)
5	Rough	(8 - 13 ft.)
6	Very rough	(13 - 20 ft.)
7	High	(20 - 30 ft.)
8	Very high	(30 - 45 ft.)
9	Phenomenal*	(Over 45 ft.)

*As might exist at the center of a hurricane

TABLE 18: W_s

0	No change
1	Marked wind shift
2	Marked turbulence begins or ends
3	Marked temperature change (not with altitude)
4	Precipitation begins or ends
5	Change in cloud forms
6	Fog bank begins or ends
7	Warm front
8	Cold front
9	Front, type not specified

TABLE 19: S_s, S_b, S_e

0	No report
1	Reported at previous position
2	Occurring at present position
3	20 nautical miles
4	40 nautical miles
5	60 nautical miles
6	80 nautical miles
7	100 nautical miles
8	150 nautical miles
9	More than 150 nautical miles

TABLE 20: W_c

0	No report
1	Signs of hurricane
2	Ugly, threatening sky
3	Duststorm or sandstorm
4	Fog or ice fog
5	Waterspout
6	Cs cloud shield or bank
7	As or Ac cloud shield or bank
8	Line of heavy cumulus
9	Cb heads or thunderstorms

TABLE 21: I_r

0	.1 in. or	2 mm./minute
1	.1 - .2 in. or	2 - 5 mm./minute
2	.3 - .4 in. or	6 - 10 mm./minute
3	.5 - .6 in. or	11 - 15 mm./minute
4	.7 - .8 in. or	16 - 20 mm./minute
5	.9 - 1.0 in. or	21 - 25 mm./minute
6	Over 1.0 in. or 25 mm./minute	
7	Light	
8	Moderate	
9	Heavy	

461 A

RECCO CODE
ological Reconnaissence Reporting Code)

DATE ____________________

ORGANIZATION ____________________

TYPE A/C ____________________

OBSERVER ____________________

Section 2 – OPTIONAL

Ascending Order																																								
Cloud Amount (3rd. layer)	Cloud Type	Altitude of Base of Cloud Type Reported by C	Altitude of Top of Cloud Type Reported by C	Cloud Type	Altitude of Base of Cloud Type Reported by C	Altitude of Top of Cloud Type Reported by C	Cloud Type	Altitude of Base of Cloud Type Reported by C	Altitude of Top of Cloud Type Reported by C	Group Indicator	Direction of Surface Wind (10s of degrees true)	Wind Speed at Surface (knots)	Group Indicator	Direction of Surface Wind	Force of Surface Wind	State of Sea	Direction of Swell	Group Indicator	Significant Changes in Weather	Distance of Occurrence of Ws	Weather Off Course	Bearing (true) of Weather Off Course	Group Indicator	Rate of Icing	Type of Icing and contrails	Distance to Beginning of Icing	Distance to Ending of Icing	Group Indicator	Altitude of Base of Icing	Altitude of Top of Icing	Group Indicator	Bearing of Echo Center from Aircraft (10s of degrees, true)	Distance to Echo Center (10s of naut. mi.)	Orientation of Ellipse	Group Indicator	Ellipse Width or Echo Diameter (10s of naut. mi.)	Length of Major Axis (10s of naut. mi.)	Character of Echo	Intensity of Echo	Plain Language Remarks
$_3$	C	hh	HH	C	hh	HH	C	hh	HH	4	dd	ff	5	D	F	S	D_K	6	W_S	S_S	W_C	D_W	7	I_r	I_t	S_b	S_e	7	h_ih_i	H_iH_i	8	d_rd_r	S_r	O_e	8	w_e	a_e	c_e	i	
	13	14		13	14		13	14						15	16	17	15		18	19	20	15		21	22	19			14					23				24	25	

5. Plain language remarks may be added at the end of the message to supplement the coded message or to supply additional information not provided for in the code.

6. The solidus (/) will be used to report missing or unknown data unless otherwise specified for the individual elements. The term "altitude" is defined as the vertical distance of a level point or an object considered as a point, measured from mean sea level.

7. If operational data or position reports are required, they will be transmitted by the aircraft prior to the 9xxx9 key group of the RECCO report. These additional operational reports will not be included in the landline teletypewriter transmission of the RECCO report.

SECTION I - MANDATORY Section of the Flight Level Portion of the Message.

8. 9xxx9 - The key group 9xxx9 indicates the dimensional unit being used and whether or not radar observations are being made. This group shall always be included in the report. If radar equipment is operational, this information shall be reported for symbol "xxx" even though no echoes are observed. The omission of the 8-groups from the report will indicate to the recipient that no echoes were observed. (Note: The units indicated by symbol "xxx" apply only to the flight level portions of the message. All altitudes of standard pressure surfaces and tropopause reported in the sounding portion of the message are given in meters and decameters in accord with the instructions given in the Manual for Radiosonde Code for reporting sounding data.)

9. GGgg and Y - The time the aircraft is on the vertical axis of the observation cylinder is reported for "GGgg". All elements are observed, insofar as practicable, when the aircraft is at the point of observation or in proximity thereto. The actual time of observation is the time at which the observing of all elements is completed. All times (GGgg) and the day of the week (Y) are given in Greenwich Mean time. The day reported

15. d_a and ddfff - When code figure 8 is reported for "d_a", five solidi (i.e., /////) are reported for the "ddfff" group. The complete specifications for Table 7 are:

TABLE 8: d_a

0	90% to 100% reliable. Multiple drift with closed wind star, or small open star when winds are 50 kts or greater. Short radar wind runs.
1	75% to 100% reliable. Multiple drift with small open star or double drift or single drift with average ground speed by timing. Short radar run.
2	80% to 100% reliable. Fix to fix winds using the following pin point visual fixes, radar fixes or accurate loran fixes using good ground waves.
3	75% to 90% reliable. Fix to fix winds using two or three lines of positions (LOPs) either loran, celestial, radio or sight bearings or any combination of the three above when all lines of position are considered reliable.
4	60% to 80% reliable. Winds obtained using single drift and single LOP (Speed Line), air-plot, etc.
5	50% to 75% reliable. Fix to fix winds using two or three lines of position either loran, celestial, radio or sight bearings or any combination of the above when one of the lines is not considered reliable.
6	Less than 50% reliable. Winds obtained by any of the above methods which the navigator believes to be inaccurate or of questionable accuracy.
7	No reliability. Assumed or estimated winds.
8	No wind. Navigator unable to determine a wind.
9	Not used.

21. k_n - When clouds are present in indefinite layers (chaotic sky) code figure 9 is reported for "k_n". If it is impossible to determine that clouds exist (due to darkness or for other reasons) a "/" is reported for "k_n". When a cloud layer is present but data on the type, the extent of coverage, and altitude can not be observed, "/'s" are reported for N, C, hh, and HH, as appropriate; however, the layer will be included in the number of layers reported for "k_n". (See Note 22.)

22. N_1,N_2,N_3 - The amount of cloud reported for N_1,N_2, etc., is the amount in the individual layer as though no other cloud were present; i.e., the summation concept is not used. The cloud layers are reported in the message in ascending order according to altitude of the base. When code figure 9 is reported for "k_n", the value reported for "N_1" is the total amount of cloud coverage present and "//" is reported for "N_2N_3". When a "/" is reported for "k_n", "999" is reported for "$N_1N_2N_3$". (See Note 21.)

23. ChhHH - This group is included in the message for each layer of clouds reported by "k_n" and described by N_1, N_2, etc.

24. C - The type of cloud predominating in the layer is reported for "C".

25. hh and HH - The average altitude of both the base and top of the cloud layer reported for "C" is reported for "hh" and "HH", respectively.

26. 4ddff and 5DFSD$_K$ - Surface data are reported in this group. Surface wind data are included in each low level report. Either or both of the groups may be included in the message if required.

27. dd - The estimated direction (true) FROM which the surface wind is blowing is reported for "dd". (See Note 28.)

Y is the day on which the observation is taken and NOT the day on which it is transmitted.

10. $L_aL_aL_a$ and $L_oL_oL_o$ - The latitude and longitude of the point, at which the flight level observation is made, are reported for "$L_aL_aL_a$" and "$L_oL_oL_o$" respectively. Tenths of a degree are obtained by dividing the number of minutes by 6, disregarding the remainder. The hundreds digit is omitted from longitudes 100° to 180°, inclusive.

11. B - The type of turbulence encountered at the time of observation is reported for "B". Definitions of the terms used to indicate the various types of turbulence reported are:

Light - A turbulent condition during which occupants may be required to use seat belts, but objects in the aircraft remain at rest.

Moderate - A turbulent condition in which occupants require seat belts and occasionally are thrown against the belt. Unsecured objects in the aircraft move about.

Severe - A turbulent condition in which the aircraft momentarily may be out of control. Occupants are thrown violently against the belt and back into the seat. Objects are secured in the aircraft are tossed about.

12. f'_c - The average flight condition existing during the time required to make the flight level observation is reported for "f'_c".

13. hhh - The true altitude of the aircraft at the time of the flight level observation is reported to the nearest hundred foot or 30 meter level (e.g., when the aircraft is 50 feet or more above a hundred foot level the next higher level is reported for "hhh").

14. d_t - When code figure 9 is reported, the distance over which the wind is averaged is added at the end of the message in plain language.

16. TT - Free air temperature (corrected for calibration, installation, and dynamic heating effects) at flight level (hhh) at the time of observation is reported for "TT" to the nearest whole degree Celsius.

When the temperature is below zero, 50 is added to the absolute value of the temperature and the sum is reported for "TT". The hundreds figure, if any, resulting from this addition is disregarded.

17. T_dT_d - When the wet bulb temperature is below -35°C., "//" is reported for "T_dT_d". Dew point is used to indicate the moisture content of the air in United States RECCO reports. (See Note 16.)

18. w - The specification most descriptive of the weather existing at the time of observation is reported for "w". Code figure 2 is reported when the total amount of cloud above or below the aircraft is 7/8 or more.

19. m - The information which best amplifies the present weather reported for "w" is reported for "m".

SECTION 2 - OPTIONAL Section of the Flight Level Portion of the Message

20. $Ik_nN_1N_2N_3$ - If data on more than three layers of cloud are reported, a second $Ik_nN_1N_2N_3$ group plus the required number of ChhHH groups are inserted in the message following the last of the first three ChhHH groups. The additional number of layers (i.e., exclusive of the first three layers) being reported is given for "k_n" in the second $Ik_nN_1N_2N_3$ group. The coverage of the additional cloud layers is reported for N_1, N_2, and N_3 in the second group, as required. When no clouds exist the $Ik_nN_1N_2N_3$ and ChhHH groups are omitted from the message.

wind is reported for "ff". In the range of 100-199 knots, inclusive, the hundreds figure is omitted and the tens and the units values are reported for "ff" and 50 is added to the value normally reported for "dd". For speeds in excess of 199 knots, "//" is reported for "ff" and the actual speed is reported in plain language at the end of the message.

29. D - The estimated direction (true) FROM which the surface wind is blowing is reported for "D".

30. F - The estimated force of the surface wind is reported. When the speed exceeds Force 9, code figure 9 is reported for "F" and a plain language remark is added at the end of the flight level portion of the message giving the actual Beaufort Force as "GALE TEN", "STORM ELEVEN", or "HURRICANE TWELVE".

31. D_K - The true direction FROM which the swell is moving is reported for "D_K". Code figure 0 is reported for "no swell" and code figure 9 is reported to indicate "confused" swell. When the waves are from several directions, the direction from which the wave of longest period is traveling is reported.

32. $6W_sS_sW_cD_w$ - Two 6-groups may be included in the message to report two significant weather changes, and/or two weather phenomena off course, or combinations thereof.

33. W_s - Significant weather changes which have occurred since the last observation, or in the preceding hour (whichever period is shorter) along the track of the aircraft are reported for "W_s".

34. S_s - The distance from the present position back to the location of the significant weather change (W_s) is reported for "S_s".

35. W_c - Any off-course weathe: condition of importance which is not included or implied in the specification reported for present weather, will be reported for "W_c". The information reported for "W_c" supplements the present weather (w). (See Notes 2, 18, 54 and 55.)

36. D_w - Code figure 9 indicates "in all directions".

37. $7I_rI_tS_bS_e$ $7h_ih_i$[illegible] - When icing occurs, both of the 7-groups shall be included in the report. The 8-groups may be repeated as often as necessary to describe the icing conditions encountered.

38. I_r - Normally only aircraft equipped with icing rate meters will report code figures 0 through 6; however, if a quantitative estimate is possible it may be reported even though the aircraft equipment does not include a meter. In general, code figures 7 through 9 are used more often than the other code figures.

United States definitions of the terms given in Table 21 used to describe the rate of ice accumulation are:

Light - An accumulation of ice which can be disposed of by the aircraft de-icing equipment, which presents no serious hazard to the flight, and which us not sufficient to cause alterations in speed, altitude, or track.

Moderate - An accumulation of ice which produces a condition intermediate between "light" and "heavy".

Heavy - An accumulation of ice which continues to increase despite operation of de-icing equipment, which is sufficiently serious to cause marked alteration in speed,

46. S_r - When the distance to the center of the echo is greater than 95 nautical miles, 100 is subtracted from the distance and the tens value of the remainder is reported for "S_r" and 50 is added to the value normally reported for "d_rd_r". When a line of echoes is observed, "S_r" is the distance to the midpoint of the line.

47. c_e - The term solid is used when the individual echoes are not distinctly and widely separated. Code figures 1, 2, 5, and 6 are used to report circular areas of echoes.

SECTION 3 - Intermediate Reports (OPTIONAL)

48. When required, intermediate observations may be taken between complete flight level observations. The intermediate data are reported in the next complete flight level message by inserting the coded groups (i.e., Section 3) in the message immediately following the last coded group of the complete flight level report. Section 3 may be attached at the end of either Section 2 or Section 1, as appropriate.

49. The use of Section 3 is OPTIONAL. If this Section is reported, all of the data groups (i.e., $GGggi_u$ through mjHHH) shall be always included in the message for each intermediate observation being reported with appropriate missing indicators being used for those elements for which datum is not available except the $(4L_aL_aL_oL_o)$ group. The self-identifying 4-group may be included or omitted as required.

50. The intermediate data groups are extracted from the complete flight level form as follows: 99999 $GGggi_u$ ddfff TTT_uT_uw mjHHH $(4L_aL_aL_oL_o)$ $GGggi_u$ ddfff ..... etc. .....

51. Unless otherwise indicated it shall be assumed that a straight-line constant-altitude flight has been made between the position of

57. Vertical ascent or descent. WMO code form FM 35.C (TEMP) shall be used to report sounding data obtained by means of either a vertical ascent or descent.

a. If the sounding data are added to the flight level report, they shall be added to Section 2 of RECCO and identified by the indicator group 17171. In this instance the groups M_iM_i and (II)iii shall be omitted from FM 35.C and the group $GGh_1h_1h_1$ shall become $00h_1h_1h_1h_1$. The form being ..... $8w_ea_ec_ei_e$ 17171 $00h_1h_1h_1$ $(T_1T_1T_{d1}T_{d1}T_{x1})$ $(0d_1d_1f_1f_1)$ $P_2P_2h_2h_2h_2$ ..... etc.

In this instance the time and position of the ascent or descent shall be given in groups $GGggi_u$ $YQL_aL_aL_a$ $L_oL_oL_oBf_c'$ of the flight level report.

b. When the data obtained by means of a vertical ascent or descent are sent as a separate report, the first four groups of Section 1 of RECCO shall be followed by FM 35.C as follows: 9xxx9 $GGggi_u$ $YQL_aL_aL_a$ $L_oL_oL_oBf_c'$ 17171 ..... etc.

58. Dropsonde. Sounding data obtained from a drop-sonde released from the aircraft shall be reported by means of WMO code form FM 36.C (TEMP SHIP). The drop-sonde data may be added either to the flight level report or sent as a separate report.

a. When the drop-sonde data are added to Section 2 of RECCO the indicator group 71717 precedes the coded sounding data (FM 36.C). In this instance two minor alterations are made in FM 36.C, the M_iM_i group is omitted from the report and GG is reported to the nearest quarter hour. The nearest quarter of an hour is indicated by adding 25, 50 or 75 to the actual number of hours.

would seriously affect the safety of the aircraft.

39. I_t - For this purpose a non-persistent contrail is defined as one which is 1/4 nautical mile or less in length and a persistent contrail is one which is over 1/4 nautical mile in length.

40. S_b - Code figure 0 is reported when the aircraft has completed an ascent or a descent, in which case the limits of icing are reported in group $7h_ih_iH_iH_i$. Code figure 2 is reported when the icing began during the time of the flight level observation and it will be an amplification of the information reported for "w" and "m".

41. S_e - Code figure 2 is reported when the icing is continuing at the time of the flight level observation.

42. h_ih_i - When the aircraft encounters icing during an ascent or descent, the altitude of the base of the icing stratum is reported for "h_ih_i". When the aircraft encounters icing during level flight, the altitude at which icing occurred is reported for "h_ih_i".

43. H_iH_i - When the aircraft encounters icing during an ascent or descent the altitude of the top of the icing stratum is reported for "H_iH_i". When the aircraft encounters icing during level flight, "//" is reported for "H_iH_i".

44. $8d_id_rS_rO_e$ $8w_ea_ec_ei_e$ - When radar data are observed, both the 8-groups shall be included in the report. The 8-groups may be repeated as often as necessary to report essential data.

45. d_rd_r - Code figure 99 is reported to indicate echoes "in all directions". (See Notes 8 and 44.)

the last reported complete flight level observation and the present one. Any intermediate observations reported in the present complete flight level report shall be assumed to have been made on this flight patch.

52. If the direction of the flight has been altered, the latitude and longitude of the turning point shall be reported by the group ($4L_aL_aL_oL_o$). The group ($4L_aL_aL_oL_o$) shall be inserted in the intermediate Reports portion of the message, as appropriate, with respect to time.

53. If the altitude of the flight is altered between any two consecutive complete flight level observations, intermediate observations shall not be reported between those two flight level reporting positions.

Plain Language Remarks

54. Plain language remarks may be added at the end of the message to supplement the coded data or to supply additional information of importance not provided for in the code. For example: Time of occurrence of significant weather (W_s), past weather, etc.

55. If information on past weather is added as a plain language remark, the most significant weather encountered since the last report, or in the last hour, whichever period of time is shorter, shall be described by the remark.

Sounding Portion of the Message

56. Sounding data are obtained during vertical ascents or descents of the aircraft or by releasing dropsondes from the aircraft. For transmission purposes these data may be added to Section 2 of RECCO or sent as a separate message.

and 07 1/2 minutes, nothing is added to the hour; e.g., times between 0152 1/2 to 0207 1/2 are coded 02. When the minute lies between 07 1/2 and 22 1/2 minutes, 25 is added to the hour; e.g., times between 0307 1/2 to 0322 1/2 are coded 28. When the minute lies between 22 1/2 and 37 1/2 minutes 50 is added to the hour; e.g., times between 1122 1/2 to 1137 1/2 are coded 61. When the minute lies between 37 1/2 to 52 1/2 minutes 75 is added to the hour; e.g., times between 2037 1/2 to 2052 1/2 are coded 95.

b. When the drop-sonde data are sent as a separate report, the TEMP SHIP form of message (FM 36.C) is preceded by the key groups 9xxx9 and 71717.

c. The location and time (to the nearest quarter hour) at which the drop-sonde was ejected from the aircraft shall be given in the $YOL_aL_aL_a$ and $L_oL_oL_oGG$ groups of TEMP SHIP (FM 36.C).

59. Following are general notes which apply to the coding of sounding data obtained by aircraft:

a. Whenever practicable extrapolated data are reported for $P_oP_oP_o$, T_oT_o and $T_{do}T_{do}$. If extrapolated data are not available for these elements, the surface groups are omitted from the report.

b. If tenths values of air and dew point temperatures are not reported, a zero is coded for T_{xo}, T_{x1}, T_{x2}, etc.

60. Sea Ice Data:

Sea ice, as observed by aircraft, are reported in the national code from (see Chapter III, Part A-4-RECCO).

APPENDIX VIII

BATHYTHERMOGRAPH LOG
(OCEANAV 3167/1)

OCEANAV 3167/1(6-72)
NOAA Form 77-22 (1-72)

BATHYTHERMOGRAPH LOG

Prepared by the OCEANOGRAPHER OF THE NAVY
and the NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
in accordance with specifications established by the
INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION (IOC)
and WORLD METEOROLOGICAL ORGANIZATION (WMO)

FOR NAVY SHIP USE

		SHIP TYPE	HULL NUMBER	YR	MON		
B	A					Z	T
1	2	3 - 4	5 - 7	12	13 - 14	15	22

FO

		SQDN TYPE	SQ
B	A		
1	2	3 - 4	5

I. REFERENCE INFORMATION

	PLATFORM		
	TYPE	NAME	DESIGNATOR
	COUNTRY	INSTITUTION	
CRUISE NUMBER	PROJECT		
STATION NUMBER	OBSERVATION NUMBER	INSTRUMENT	

II. OPTIONAL ENVIRONMENTAL INFORMATION

DEPTH TO BOTTOM (METERS) 1	WIND 2				SEA LEVEL PRESSURE 3				AIR TEMP 4				AIR TEMP 5			
		DIR		SPEED					±	DRY BULB			±	WET BULB		
	i_u	d	d	f	f	P	P	P	P	S_n	T	T	T	S_n	T	T	T

SEA TEMP 6				WAVE 7				SWELL 8					SOLAR RADIATION 9	PRECIP 10		TRANS 11
°C			INSTR	PER		HT		DIR		PER	HT					
T_w	T_w	T_w		P_w	P_w	H_w	H_w	d_w	d_w	P_w	H_w	H_w	LANG/MIN	R	R	METERS

I. REFERENCE INFORMATION

STATION NUMBER	OBSERVATION NUMBER	INSTRUMENT

II. OPTIONAL ENVIRONMENTAL INFORMATION

DEPTH TO BOTTOM (METERS) 1	WIND 2				SEA LEVEL PRESSURE 3				AIR TEMP 4				AIR TEMP 5			
		DIR		SPEED					±	DRY BULB			±	WET BULB		
	i_u	d	d	f	f	P	P	P	P	S_n	T	T	T	S_n	T	T	T

SEA TEMP 6				WAVE 7				SWELL 8					SOLAR RADIATION 9	PRECIP 10		TRANS 11
°C			INSTR	PER		HT		DIR		PER	HT					
T_w	T_w	T_w		P_w	P_w	H_w	H_w	d_w	d_w	P_w	H_w	H_w	LANG/MIN	R	R	METERS

I. REFERENCE INFORMATION

STATION NUMBER	OBSERVATION NUMBER	INSTRUMENT

II. OPTIONAL ENVIRONMENTAL INFORMATION

DEPTH TO BOTTOM (METERS) 1	WIND 2				SEA LEVEL PRESSURE 3				AIR TEMP 4				AIR TEMP 5			
		DIR		SPEED					±	DRY BULB			±	WET BULB		
	i_u	d	d	f	f	P	P	P	P	S_n	T	T	T	S_n	T	T	T

SEA TEMP 6				WAVE 7				SWELL 8					SOLAR RADIATION 9	PRECIP 10		TRANS 11
°C			INSTR	PER		HT		DIR		PER	HT					
T_w	T_w	T_w		P_w	P_w	H_w	H_w	d_w	d_w	P_w	H_w	H_w	LANG/MIN	R	R	METERS

REMARKS: 466

III. RADIO MESSAGE INFORMATION

1 MESSAGE PREFIX				2 DATE (GMT)					3 TIME (GMT)					4 QUAD	LATITUDE				LO
				DAY		MONTH		YR	HOUR		MIN.				DEG.		MIN.		DEC
M_i	M_i	M_j	M_j	Y	Y	M	M	J	G	G	g	g		Q_c	L_a	L_a	L_a	L_a	L_o L_o
J	J	X	X										/						
				16	17				18	-	21			23	-			27	28

BATHYTHERMOGRAPH TRACE READINGS

DEPTH		TEMP			DEPTH		TEMP			DEPTH		TEMP			DEPTH		TEMP			DEPTH
z_0	z_0	T_0	T_0	T_0	z	z	T	T	T	z	z	T	T	T	z	z	T	T	T	z
0	0																			
z	z	T	T	T	z	z	T	T	T	z	z	T	T	T	z	z	T	T	T	z
z	z	T	T	T	z	z	T	T	T	z	z	T	T	T	z	z	T	T	T	z
38	-			42	43	-			47	48	-			52	53	-			57	58

1 MESSAGE PREFIX				2 DATE (GMT)					3 TIME (GMT)					4 QUAD	LATITUDE				LO
				DAY		MONTH		YR	HOUR		MIN.				DEG.		MIN.		DEC
M_i	M_i	M_j	M_j	Y	Y	M	M	J	G	G	g	g		Q_c	L_a	L_a	L_a	L_a	L_o L_o
J	J	X	X										/						
				16	17				18	-	21			23	-			27	28

BATHYTHERMOGRAPH TRACE READINGS

DEPTH		TEMP			DEPTH		TEMP			DEPTH		TEMP			DEPTH		TEMP			DEPTH
z_0	z_0	T_0	T_0	T_0	z	z	T	T	T	z	z	T	T	T	z	z	T	T	T	z
0	0																			
z	z	T	T	T	z	z	T	T	T	z	z	T	T	T	z	z	T	T	T	z
z	z	T	T	T	z	z	T	T	T	z	z	T	T	T	z	z	T	T	T	z
38	-			42	43	-			47	48	-			52	53	-			57	58

1 MESSAGE PREFIX				2 DATE (GMT)					3 TIME (GMT)					4 QUAD	LATITUDE				LO
				DAY		MONTH		YR	HOUR		MIN.				DEG.		MIN.		DE
M_i	M_i	M_j	M_j	Y	Y	M	M	J	G	G	g	g		Q_c	L_a	L_a	L_a	L_a	L_o
J	J	X	X										/						
				16	17				18	-	21			23	-			27	28

BATHYTHERMOGRAPH TRACE READINGS

DEPTH		TEMP			DEPTH		TEMP			DEPTH		TEMP			DEPTH		TEMP			DEPTH
z_0	z_0	T_0	T_0	T_0	z	z	T	T	T	z	z	T	T	T	z	z	T	T	T	z
0	0																			
z	z	T	T	T	z	z	T	T	T	z	z	T	T	T	z	z	T	T	T	z
z	z	T	T	T	z	z	T	T	T	z	z	T	T	T	z	z	T	T	T	z
38	-			42	43	-				48	-			52	53	-			57	58

R

BATHYTHERMOGRAPH LOG

FORM APPROVED
OMB NO. 41R2646

Prepared by the OCEANOGRAPHER OF THE NAVY
and the NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
in accordance with specifications established by the
INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION (IOC)
and WORLD METEOROLOGICAL ORGANIZATION (WMO)

FOR NAVY AIRCRAFT USE

		SQDN TYPE	SQDN NMBR	SORTIE NUMBER	YR	MON		
B	A						Z	T
1	2	3 - 4	5 - 7	8 - 11	12	13 - 14	15	22

DESIGNATOR

ON

AIR TEMP 5
WET BULB
T T T

10 RECIP
11 TRANS
R R
METERS

III. RADIO MESSAGE INFORMATION

1 MESSAGE PREFIX	2 DATE (GMT)	3 TIME (GMT)	QUAD 4 LATITUDE	5 LONGITUDE	6 INDICATOR GROUP
M_i M_i M_j M_j	DAY MONTH YR Y Y M M J	HOUR MIN G G g g	Q_c DEG MIN L_a L_a L_a L_a	DEG. MIN. L_o L_o L_o L_o L_o	
J J X X		/			8 8 8 8 8
	16 17	18 - 21	23 - 27	28 - 32	

BATHYTHERMOGRAPH TRACE READINGS

DEPTH TEMP	DEPTH TEMP	DEPTH TEMP	DEPTH TEMP	DEPTH TEMP	DEPTH TEMP
Z_0 Z_0 T_0 T_0 T_0	z z T_z T_z T_z	z z T_z T_z T_z	z z T_z T_z T_z	z z T_z T_z T_z	z z T_z T_z T_z
0 0					
z z T_z T_z T_z	z z T_z T_z T_z	z z T_z T_z T_z	z z T_z T_z T_z	z z T_z T_z T_z	z z T_z T_z T_z
z z T_z T_z T_z	z z T_z T_z T_z	z z T_z T_z T_z	z z T_z T_z T_z	z z T_z T_z T_z	RADIO CALL
38 - 42	43 - 47	48 - 52	53 - 57	58 - 62	63 - 67

ON

AIR TEMP 5
WET BULB
T T T

10 RECIP
11 TRANS
R R
METERS

1 MESSAGE PREFIX	2 DATE (GMT)	3 TIME (GMT)	QUAD 4 LATITUDE	5 LONGITUDE	6 INDICATOR GROUP
M_i M_i M_j M_j	DAY MONTH YR. Y Y M M J	HOUR MIN G G g g	Q_c DEG. MIN. L_a L_a L_a L_a	DEG. MIN. L_o L_o L_o L_o L_o	
J J X X		/			8 8 8 8 8
	16 17	18 - 21	23 - 27	28 - 32	

BATHYTHERMOGRAPH TRACE READINGS

DEPTH TEMP	DEPTH TEMP	DEPTH TEMP	DEPTH TEMP	DEPTH TEMP	DEPTH TEMP
Z_0 Z_0 T_0 T_0 T_0	z z T_z T_z T_z	z z T_z T_z T_z	z z T_z T_z T_z	z z T_z T_z T_z	z z T_z T_z T_z
0 0					
z z T_z T_z T_z	z z T_z T_z T_z	z z T_z T_z T_z	z z T_z T_z T_z	z z T_z T_z T_z	z z T_z T_z T_z
z z T_z T_z T_z	z z T_z T_z T_z	z z T_z T_z T_z	z z T_z T_z T_z	z z T_z T_z T_z	RADIO CALL
38 - 42	43 - 47	48 - 52	53 - 57	58 - 62	63 - 67

N

AIR TEMP 5
WET BULB
T T T

10 RECIP
11 TRANS
R R
METERS

1 MESSAGE PREFIX	2 DATE (GMT)	3 TIME (GMT)	QUAD 4 LATITUDE	5 LONGITUDE	6 INDICATOR GROUP
M_i M_i M_j M_j	DAY MONTH YR Y Y M M J	HOUR MIN G G g g	Q_c DEG. MIN L_a L_a L_a L_a	DEG. MIN. L_o L_o L_o L_o L_o	
J J X X		/			8 8 8 8 8
	16 17	18 - 21	23 - 27	28 - 32	

BATHYTHERMOGRAPH TRACE READINGS

DEPTH TEMP	DEPTH TEMP	DEPTH TEMP	DEPTH TEMP	DEPTH TEMP	DEPTH TEMP
Z_0 Z_0 T_0 T_0 T_0	z z T_z T_z T_z	z z T_z T_z T_z	z z T_z T_z T_z	z z T_z T_z T_z	z z T_z T_z T_z
0 0					
z z T_z T_z T_z	z z T_z T_z T_z	z z T_z T_z T_z	z z T_z T_z T_z	z z T_z T_z T_z	z z T_z T_z T_z
z z T_z T_z T_z	z z T_z T_z T_z	z z T_z T_z T_z	z z T_z T_z T_z	z z T_z T_z T_z	RADIO CALL
38 - 42	43 -	48 - 52	53 - 57	58 - 62	63 - 67

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APPENDIX IX

WEATHER DATA DESIGNATORS

APPENDIX-DATA DESIGNATORS

TYPE OF REPORT

SURFACE DATA

SA - Aviation hourlies
SD - Radar summary data
SI - Three hourly synops (intermediate)
SM - Six hourly synops
SP - Aviation specials
SX - Miscellaneous

UPPER AIR DATA

UA - Aircraft Report (Pirep)
UI - Pilot/Pilot Ship (parts A & B) data
UJ - Upper wind, temp, and constant pressure height data
UP - Pibal data
UR - Reconnaissance Flight (regular)
US - Radiosonde/Rawinsonde
UW - Rawin
UX - Miscellaneous

FORECASTS AND PROGNOSIS

FA - Area Forecast
FB - Domestic Route Forecast
FD - Upper wind and temp forecasts
FF - Flight Forecasts
FP - Planning Forecast
FR - Route Forecasts
FS - Surface Prognostic Chart
FT - Terminal Forecasts
FU - Upper Air Prognostic Chart
FX - Miscellaneous

ANALYSIS

AP - Weather Summaries
AS - Surface
AT - Three hourly
AU - Upper Air
AW - Wind

WARNINGS

WH - Hurricane Warnings (Advisories)
WW - Weather Warnings other than hurricanes and typhoons

MISCELLANEOUS

AB - Miscellaneous Weather Summaries
DF - Fallout Data
MT - Sea surface temp.
OA - ASRAP

LOCATION INDICATORS

AMML - Balboa, Canal Zone
KAWN - Carswell AFB, Texas
KNKA - Kansas City, Mo.
KWBC - Washington, D.C.
MKPB - Barbados (off Venezuela)
RPMK - Clark AFB, Philippines

GEOGRAPHICAL DESIGNATORS

AF - Africa
AK - Alaska
AU - Australia
BE - Bermuda
BS - Bering Sea
CA - Caribbean
CD - Cambodia
CN - Canada
CU - Cuba
FR - France
GA - Gulf of Alaska
GL - Greenland
GX - Gulf of Mexico
HW - Hawaiian Islands
JP - Japan
MX - Mexico
NA - North America
NT - North Atlantic
PA - Pacific
PM - Panama, Canal Zone
US - United States
VN - Vietnam
XX - Miscellaneous

APPENDIX X

AN NOMENCLATURE SYSTEM

Part 1.—Equipment indicator letters.

Installation	Type of equipment	Purpose
A—Airborne	A—Invisible light, heat radiation.	A—Auxiliary assemblies (not complete operating sets).
B—Underwater mobile, submarine.	C—Carrier.	B—Bombing.
D—Pilotless carrier.	D—Radiac.	C—Communications (receiving and transmitting).
F—Fixed.	E—Nupac (nuclear protection and control).	D—Direction finder, reconnaissance and/or surveillance.
G—Ground, general ground use (includes two or more ground installations).	F—Photographic	E—Ejection and/or release.
K—Amphibious.	G—Telegraph or teletype.	G—Fire control or search-light directing.
M—Ground, mobile (installed as operating unit in a vehicle which has no functions other than transporting the equipment).	I—Interphone and public address.	H—Recording and/or reproducing (graphic meteorological and sound.)
P—Pack or portable (animal or man).	J—Electromechanical (not otherwise covered).	K—Computing.
S—Water surface craft.	K—Telemetering.	M—Maintenance and test assemblies (including tools).
T—Ground, transportable	L—Countermeasure.	N—Navigational aids (including altimeters, beacons, compasses, racons, depth sounding, approach, and landing).
U—General utility (includes two or more general installation classes, airborne, shipboard, and ground)	M—Meteorological.	Q—Special or combination of purposes.
	N—Sound in air.	R—Receiving, passive detecting.
	P—Radar.	S—Detecting and/or range and bearing, search.
	Q—Sonar and underwater sound.	
	R—Radio.	

Part 1.—Equipment indicator letters—Continued

Installation	Type of equipment	Purpose
V—Ground, vehicular (installed in vehicle designed for functions other than carrying electronic equipment, such as tanks).	S—Special types (magnetic, etc.) or combination of types.	T—Transmitting.
W—Water, surface and undersurface.	T—Telephone (wire).	W—Automatic flight or remote control.
	V—Visual and visible lights.	X—Identification and recognition.
	W—Armament (peculiar to armament, not otherwise covered).	
	X—Facsimile or television.	

Part 2—Component indicators.

Component indicator	Family name	Definition of example (not to be construed as limiting the application of the component indicator)
AM	Amplifiers	Power, audio, interphone, radiofrequency, video, etc.
AT	Antenna	Simple: ship or telescopic, loop, dipole, reflector, also transducer, etc.
BA	Battery, primary type	Batteries, battery packs, etc.
BB	Battery, secondary type	Storage batteries, battery packs, etc.
C	Controls	Control box, remote tuning control, etc.
CP	Computers	A mechanical and/or electronic mathematical calculating device.
CV	Converters (electronic)	Electronic apparatus for changing phase or frequency, or from one medium to another.
FR	Frequency measuring devices	Frequency meters, echo boxes, etc.
G	Generators	Electrical power generators without prime movers.

Part 2—Component indicators—Continued

Component indicator	Family name	Definition of example (not to be construed as limiting the application of the component indicator)
ID	Indicating devices	Calibrated dials and meters, indicating lights, etc. (See IP.)
IP	Indicators, cathode ray tube	Azimuth elevation, PPI panoramic, etc.
M	Microphones	Radio telephone, throat, hand, etc.
MD	Modulators	Device for varying amplitude, frequency, or both.
ME	Meters, portable	Multimeters, volt-ohm milliammeters, vacuum tube voltmeters, power meters, etc.
MK	Miscellaneous kits	Maintenance, modification, etc., except tool and crystal.
ML	Meteorological device	Barometer, hygrometer, thermometer, scales, etc.
MT	Mountings	Mountings, racks, frames, stands, etc.
PH	Photographic articles	Camera, projector, sensitometer, etc.
PT	Plotting equipments	Except meteorological boards, maps, plotting table, etc.
R	Receivers	Receivers, all types except telephone.
RD	Recorders-reproducers	Sound, graphic, tape, wire, film, disk facsimile, magnetic, mechanical, etc.
RF	Radiofrequency component	Composite component of RF circuits. (Do not use if better indicator is available.)
RG	Cables and transmissions line, bulk RF	RF cable, waveguide, etc., without terminal.
RO	Recorders	Sound, graphic, tape, wire, film, disk facsimile, magnetic, mechanical, etc.
RR	Reflectors	Target confusion, etc. Except antenna reflectors. (See AT.)
RT	Receiver and transmitter	Radio and radar transceivers, composite transmitters and receivers, etc.

Part 2—Component indicators—Continued

Component indicator	Family name	Definition of example (not to be construed as limiting the application of the component indicator)
S	Shelters	House, tent, protective shelter, etc.
SB	Switchboards	Telephone, fire control, power panel, etc.
SG	Signal generators	Includes test oscillators and noise generators.
SM	Simulators	Flight, aircraft, target, signal, etc.
SN	Synchronizers	Equipment to coordinate two or more functions.
T	Transmitters	Transmitters, all types except telephone.
TA	Telephone apparatus	Miscellaneous telephone equipment.
TD	Timing device	Mechanical and electronic timing devices, range devices, etc.
TF	Transformers	Transformers when used as separate items.
TS	Test equipment	Test and measuring equipment.
TT	Teletypewriter and facsimile apparatus	Miscellaneous tape, teletype, facsimile.

APPENDIX XI

ELECTRICAL AND ELECTRONIC TERMS

ALTERNATING CURRENT (a-c).—Current in which the change-flow periodically reverses, as opposed to direct current (d-c), and whose average value is zero.

AMPLIFIER.—A device used to increase the signal voltage, current, or power, generally composed of a vacuum tube and associated circuit called a stage. It may contain several stages in order to obtain a desired gain.

AMPLITUDE.—The maximum instantaneous value of an alternating voltage or current, measured in either the positive or negative direction.

ANTENNA.—A conductor or system of conductors for radiating or receiving radio waves.

BATTERY.—Two or more primary or secondary cells connected together electrically. The term does not apply to a single cell.

BLACK SIGNAL.—The signal at any point in a facsimile system produced by the scanning of a maximum density area of the chart copy.

CARRIER FREQUENCY.—The frequency of an unmodulated carrier wave. The RF component of a transmitted wave upon which an audio signal or other form of intelligence can be impressed.

CIRCUIT.—The complete path of an electric current.

CIRCUIT BREAKER.—An electromagnetic or thermal device that opens a circuit when the current in the circuit exceeds a predetermined amount.

COAXIAL CABLE.—A transmission line consisting of one conductor, usually a small copper tube or wire, within and insulated from another conductor of large diameter. Radiation from this type of line is practically zero.

CONDUCTOR.—Any material suitable for carrying electric current.

CYCLE.—One complete positive and one complete negative alternation of a current or voltage.

DIPOLE ANTENNA.—An antenna one-half wavelength long.

DIRECT CURRENT.—An electric current that flows in one direction only.

ELECTRON.—A negatively charged particle of matter.

ENERGY.—The ability or capacity to do work.

FREQUENCY.—The number of complete cycles per second existing in any form of wave motion; such as the number of cycles per second of an alternating current.

FREQUENCY METER.—A meter calibrated to measure frequency.

FREQUENCY MODULATION.—The process of varying the frequency of an RF carrier wave in accordance with the amplitude and frequency of an audio signal. The amplitude of the modulated wave stays constant.

FUSE.—A protective device inserted in series with a circuit. It contains a metal that will melt or break when current is increased beyond a specific value for a definite period of time.

GAIN.—The ratio of the output power, voltage, or current to the input power, voltage, or current, respectively.

GENERATOR.—A machine that converts mechanical energy into electrical energy.

GROUND.—A metallic connection with the earth to establish ground potential. Also, a common return to a point of zero potential. The chassis of a receiver or a transmitter is sometimes the common return, and therefore the "ground" of the unit.

HERTZ.—The international unit of frequency. One hertz, abbreviated Hz, is equivalent to one cycle per second.

HETERODYNE.—The production of a difference frequency (beat) by combining two frequencies. The beat frequency, being lower than the original frequency, is more readily amplified.

INTERMEDIATE FREQUENCY.—The fixed frequency to which all RF carrier waves are converted in a superheterodyne receiver.

KILOHERTZ.—One thousand hertz and abbreviated kHz.

LOUDSPEAKER.—A device that converts AF electrical energy to sound energy.

MICRO.—A prefix meaning one-millionth.

MILLI.—A prefix meaning one-thousandth.

MEGAHERTZ.—One million cycles per second and abbreviated MHz.

MICROPHONE.—A device for converting sound energy into AF electrical energy.

MODULATION.—The process of varying the amplitude (amplitude modulation), the frequency (frequency modulation), or the phase (phase modulation) of a carrier wave in accordance with other signals in order to convey intelligence. The modulating signal may be an audiofrequency signal, video signal, or electrical pulses or tones to operate relays, etc.

NEGATIVE CHARGE.—The electrical charge carried by a body which has an excess of electrons.

NEUTRON.—A particle having the weight of a proton but carrying no electric charge. It is located in the nucleus of an atom.

NUCLEUS.—The central part of an atom that comprises protons and neutrons. It is the the part of the atom that has the most mass.

OHM.—The unit of electrical resistance.

OPEN CIRCUIT.—A circuit that does not provide a complete path for the flow of current.

OSCILLOSCOPE.—An instrument for showing visually graphical representations of the waveforms encountered in an electrical circuit.

OUTPUT.—The energy delivered by a device or circuit such as a radio receiver or transmitter.

POSITIVE CHARGE.—The electrical charge carried by a body which has become deficient in electrons.

POWER.—The rate of doing work or the rate of expending energy. The unit of electrical power is the watt.

PROTON.—A positively charged particle in the nucleus of an atom.

PULSATING CURRENT.—A direct current, which periodically increases and decreases in value.

RADIATE.—To send out energy into space, as RF waves.

RADIO.—The science of communications in which RF waves are used to carry intelligence through space.

RADIOFREQUENCY.—Any frequency of electrical energy capable of propagation into space. Frequencies normally are much higher than those associated with sound waves.

RECTIFIERS.—Devices used to change alternating current to unindirectional current. These may be vacuum tubes, semi-conductors such as germanium and silicon, dry-disk rectifiers such as selenium and copper-oxide, and certain other types of crystal.

SHORT WAVE.—Refers to radio operation on frequencies higher than those normally used for commercial broadcasting. The range of frequencies extend from 1500 kc to 30,000 kc.

SUPERHETERODYNE RECEPTION.—A method of receiving radio waves in which the process of heterodyne reception is used to convert the voltage of the received wave into a voltage of an intermediate frequency.

TRANSCEIVER.—A combination of radio transmitting and receiving equipment in a single housing.

TRANSMISSION LINE.—Any conductor or system of conductors used to carry electrical energy from its source to a load.

TRANSMITTER.—Equipment used for generating and amplifying a radiofrequency signal and radiating modulated radiofrequency carrier into space as waves.

TUNING.—The process of adjusting a radio circuit to resonance with the desired frequency.

VOLT.—The unit of electrical potential.

VOLTMETER.—An instrument for measuring an electromotive force, or difference in electrical potential, by volts.

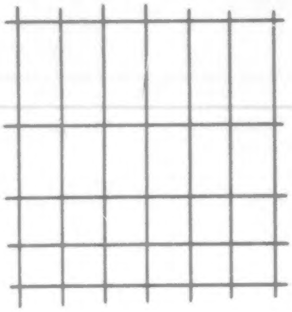
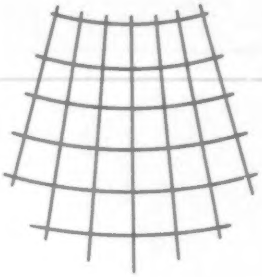
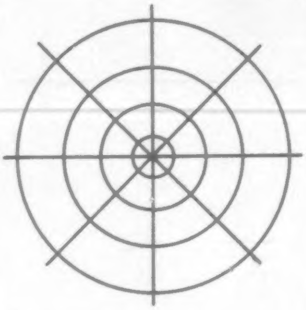
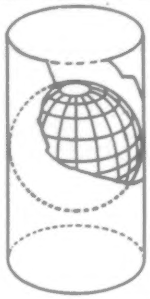
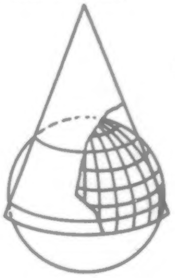
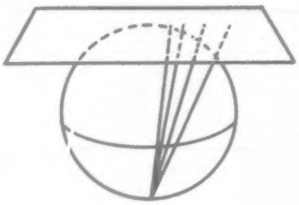
VOLUME.—A term used to denote the sound intensity (amount of radio output) of a receiver or audio amplifier.

WAVE.—A periodic variation of an electrical current or voltage.

WAVELENGTH.—The distance measured in the direction of progression of a wave from any given point to the next point characterized by the same phase.

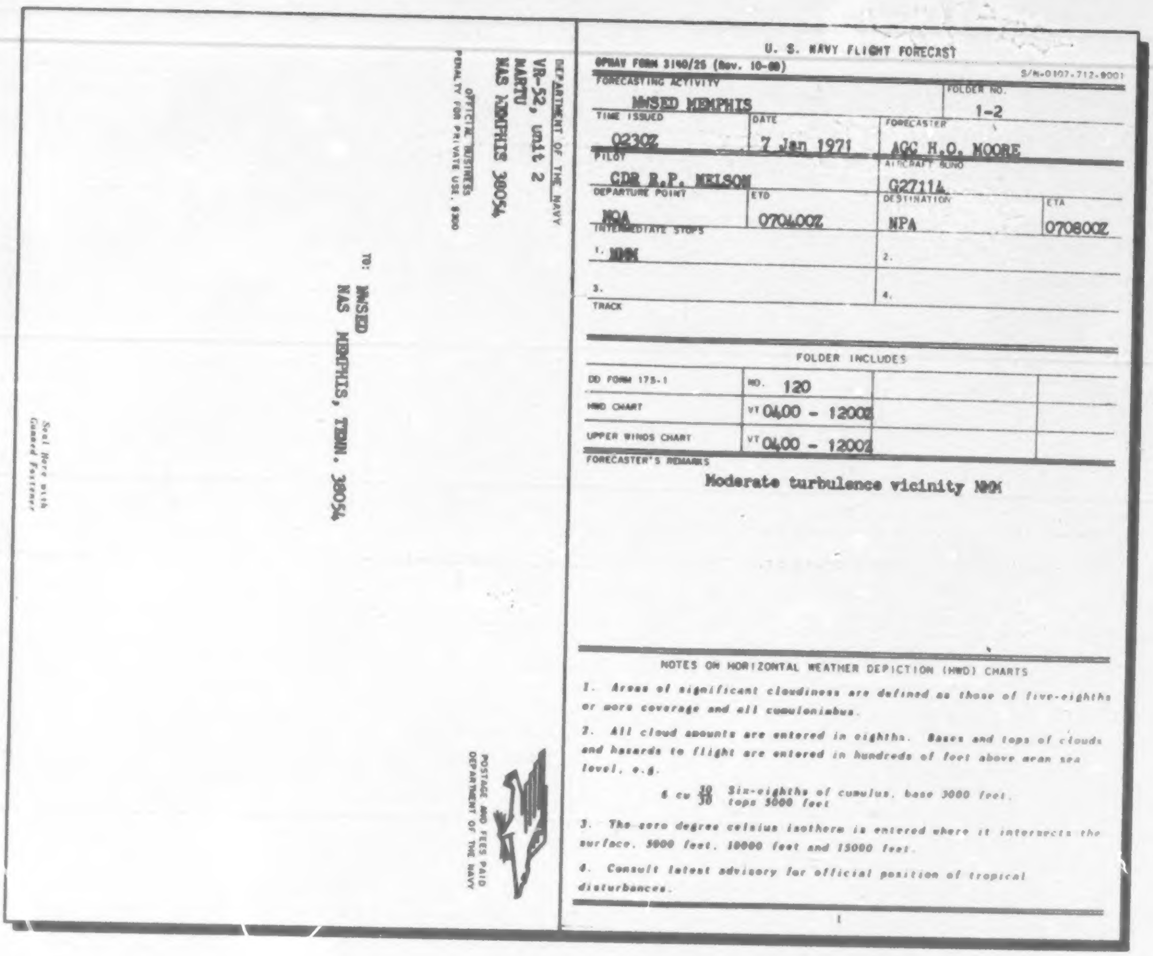
APPENDIX XII

MAP PROJECTIONS

	MERCATOR	LAMBERT CONFORMAL CONIC	POLAR STEREOGRAPHIC
PARALLEL	PARALLEL STRAIGHT LINES UNEQUALLY SPACED.	ARCS OF CONCENTRIC CIRCLES EQUALLY SPACED.	ARCS OF CONCENTRIC CIRCLES UNEQUALLY SPACED.
MERIDIAN	PARALLEL STRAIGHT LINES EQUALLY SPACED.	STRAIGHT LINES CONVERGING AT A POINT OUTSIDE OF MAP.	STRAIGHT LINES RADIATING FROM POLE.
APPEARANCE OF GRATICULE			
PROJECTED ON	CIRCUMSCRIBED CYLINDER 	SECANT CONE 	PLANE TANGENT AT POLE 
PROPERTIES	STRAIGHT LINES ARE RHUMB LINES. CONFORMAL. CONVENIENT PLOTTING. TRUE AREAS NOT SHOWN. STRAIGHT LINES NOT GREAT CIRCLES. TRUE DISTANCES NOT SHOWN. GREAT DISTORTION IN HIGH LATITUDES.	TRUE SHAPES. AREAS GOOD. DISTANCE GOOD. TRUE DIRECTIONS. SMALL NORTH-SOUTH LIMIT OF PROJECTION FOR ACCURACY. PLOTTING FAIR. NOT SATISFACTORY FOR AREAS CLOSE TO EQUATOR.	TRUE SHAPE. ONLY AZIMUTHAL PROJECTION WITH NO ANGULAR DISTORTION. TRUE AREAS NOT SHOWN. SCALE INCREASES IN ALL DIRECTIONS FROM CENTER.
USES	USED FOR AREAS CENTERED IN TROPICAL LATITUDES.	USED FOR AREAS CENTERED IN MIDDLE LATITUDES.	USED FOR NORTHERN AND SOUTHERN HEMISPHERE HIGH LATITUDES.

APPENDIX XIII

FLIGHT FORECAST FOLDER (OPNAV FORM 3140/25)



DEPARTMENT OF THE NAVY
VR-52, unit 2
NARTU
NAS MEMPHIS 38054

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

TO: NWSED
NAS MEMPHIS, TENN. 38054

Seal Here with
Gummed Fastener

POSTAGE AND FEES PAID
DEPARTMENT OF THE NAVY

U. S. NAVY FLIGHT FORECAST

OPNAV FORM 3140/25 (Rev. 10-68)

S/N-0107-712-9001

FORECASTING ACTIVITY NWSED MEMPHIS			FOLDER NO. 1-2
TIME ISSUED 0230Z	DATE 7 Jan 1971	FORECASTER AGC H.O. MOORE	
PILOT CDR R.P. NELSON		AIRCRAFT BUNO G27114	
DEPARTURE POINT NQA	ETD 070400Z	DESTINATION NPA	ETA 070800Z
INTERMEDIATE STOPS 1. NMM		2.	
3.		4.	
TRACK			

FOLDER INCLUDES

DD FORM 175-1	NO. 120		
HWD CHART	VT 0400 - 1200Z		
UPPER WINDS CHART	VT 0400 - 1200Z		

FORECASTER'S REMARKS

Moderate turbulence vicinity NMM

NOTES ON HORIZONTAL WEATHER DEPICTION (HWD) CHARTS

1. Areas of significant cloudiness are defined as those of five-eighths or more coverage and all cumulonimbus.

2. All cloud amounts are entered in eighths. Bases and tops of clouds and hazards to flight are entered in hundreds of feet above mean sea level, e.g.

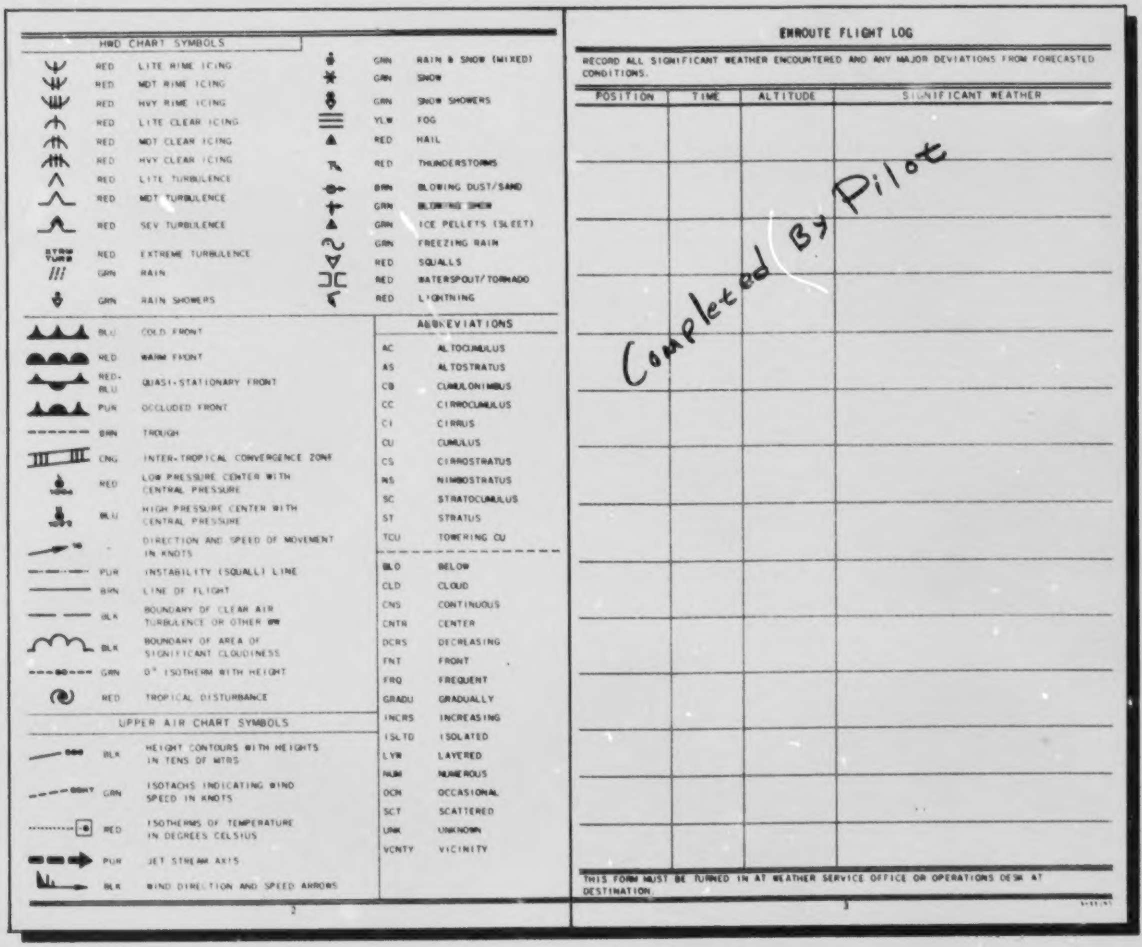
$6 \text{ cu } \frac{50}{30}$ Six-eighths of cumulus, base 3000 feet, tops 5000 feet

3. The zero degree celsius isotherm is entered where it intersects the surface, 5000 feet, 10000 feet and 15000 feet.

4. Consult latest advisory for official position of tropical disturbances.

1

Appendix XIII—FLIGHT FORECAST FOLDER (OPNAV FORM 3140/25)



HWD CHART SYMBOLS

RED	LITE RIME ICING
RED	MDT RIME ICING
RED	HVY RIME ICING
RED	LITE CLEAR ICING
RED	MDT CLEAR ICING
RED	HVY CLEAR ICING
RED	LITE TURBULENCE
RED	MDT TURBULENCE
RED	SEV TURBULENCE
RED	EXTREME TURBULENCE
GRN	RAIN
GRN	RAIN SHOWERS
GRN	RAIN & SNOW (MIXED)
GRN	SNOW
GRN	SNOW SHOWERS
YLW	FOG
RED	HAIL
RED	THUNDERSTORMS
BRN	BLOWING DUST/SAND
GRN	BLOWING SNOW
GRN	ICE PELLETS (SLEET)
GRN	FREEZING RAIN
RED	SQUALLS
RED	WATERSPOUT/TORNADO
RED	LIGHTNING
BLU	COLD FRONT
RED	WARM FRONT
RED-BLU	QUASI-STATIONARY FRONT
PUR	OCCLUDED FRONT
BRN	TROUGH
CNG	INTER-TROPICAL CONVERGENCE ZONE
RED	LOW PRESSURE CENTER WITH CENTRAL PRESSURE
BLU	HIGH PRESSURE CENTER WITH CENTRAL PRESSURE
-	DIRECTION AND SPEED OF MOVEMENT IN KNOTS
PUR	INSTABILITY (SQUALL) LINE
BRN	LINE OF FLIGHT
BLK	BOUNDARY OF CLEAR AIR TURBULENCE OR OTHER WX
BLK	BOUNDARY OF AREA OF SIGNIFICANT CLOUDINESS
GRN	0° ISOTHERM WITH HEIGHT
RED	TROPICAL DISTURBANCE

UPPER AIR CHART SYMBOLS

BLK	HEIGHT CONTOURS WITH HEIGHTS IN TENS OF MTRS
GRN	ISOTACHS INDICATING WIND SPEED IN KNOTS
RED	ISOTHERMS OF TEMPERATURE IN DEGREES CELSIUS
PUR	JET STREAM AXIS
BLK	WIND DIRECTION AND SPEED ARROWS

ABBREVIATIONS

AC	ALTOCUMULUS
AS	ALTOSTRATUS
CB	CUMULONIMBUS
CC	CIRROCUMULUS
CI	CIRRUS
CU	CUMULUS
CS	CIRROSTRATUS
NS	NIMBOSTRATUS
SC	STRATOCUMULUS
ST	STRATUS
TCU	TOWERING CU
BLO	BELOW
CLD	CLOUD
CNS	CONTINUOUS
CNTR	CENTER
DCRS	DECREASING
FNT	FRONT
FRQ	FREQUENT
GRADU	GRADUALLY
INCRS	INCREASING
ISLTD	ISOLATED
LYR	LAYERED
NUM	NUMEROUS
OCNL	OCCASIONAL
SCT	SCATTERED
UNK	UNKNOWN
VCNTY	VICINITY

2

ENROUTE FLIGHT LOG

RECORD ALL SIGNIFICANT WEATHER ENCOUNTERED AND ANY MAJOR DEVIATIONS FROM FORECASTED CONDITIONS.

POSITION	TIME	ALTITUDE	SIGNIFICANT WEATHER

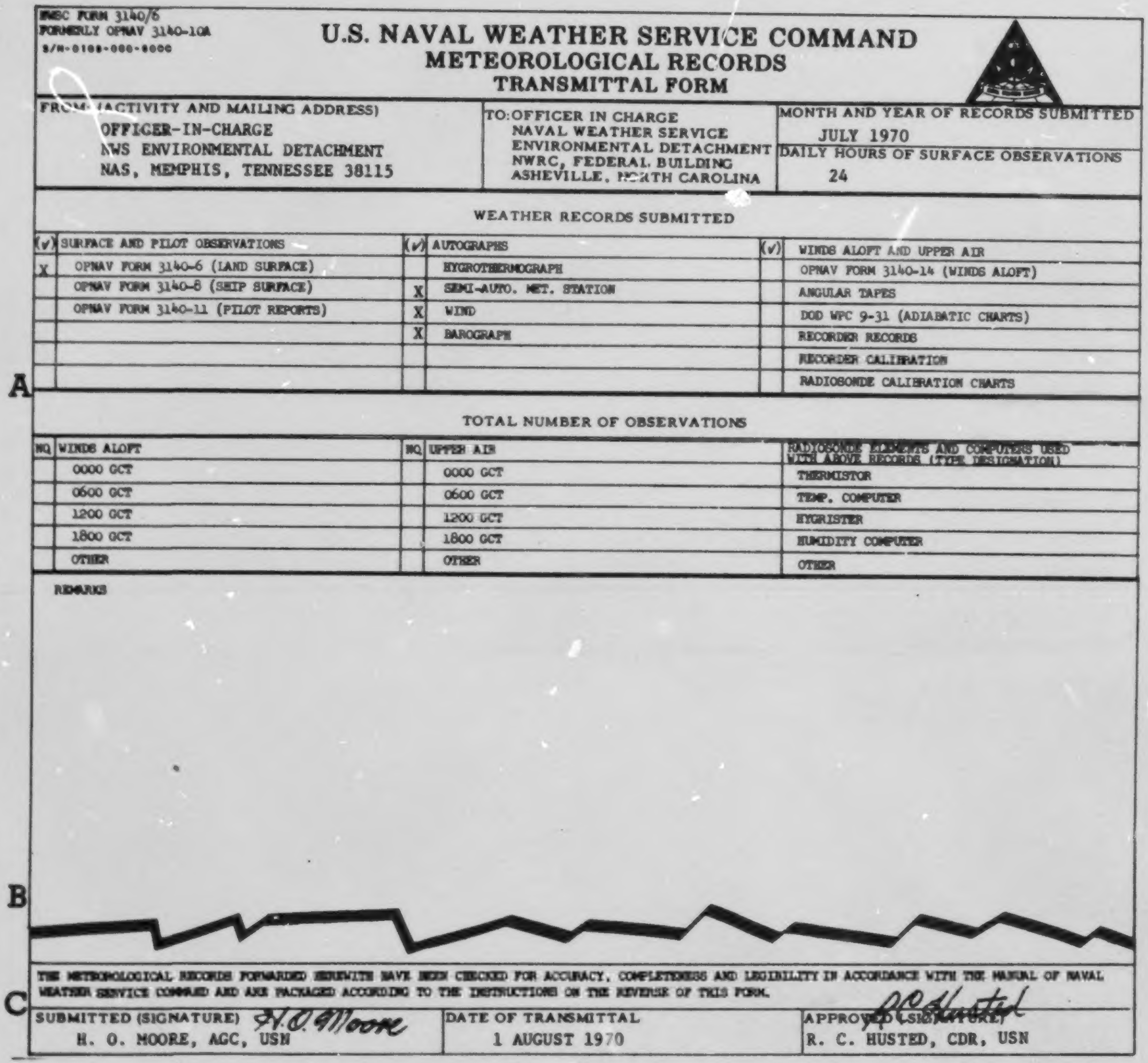
Completed By Pilot

THIS FORM MUST BE TURNED IN AT WEATHER SERVICE OFFICE OR OPERATIONS DESK AT DESTINATION.

3

APPENDIX XIV

NAVAL WEATHER SERVICE COMMAND METEOROLOGICAL RECORDS TRANSMITTAL FORM (NWSC FORM 3140/6)



NWSC FORM 3140/6
FORMERLY OPNAV 3140-10A
S/N-0108-000-8000

U.S. NAVAL WEATHER SERVICE COMMAND
METEOROLOGICAL RECORDS
TRANSMITTAL FORM

FROM: (ACTIVITY AND MAILING ADDRESS)
OFFICER-IN-CHARGE
NWS ENVIRONMENTAL DETACHMENT
NAS, MEMPHIS, TENNESSEE 38115

TO: OFFICER IN CHARGE
NAVAL WEATHER SERVICE
ENVIRONMENTAL DETACHMENT
NWRC, FEDERAL BUILDING
ASHEVILLE, NORTH CAROLINA

MONTH AND YEAR OF RECORDS SUBMITTED: JULY 1970

DAILY HOURS OF SURFACE OBSERVATIONS: 24

WEATHER RECORDS SUBMITTED

(✓)	SURFACE AND PILOT OBSERVATIONS	(✓)	AUTOGRAPHS	(✓)	WINDS ALOFT AND UPPER AIR
X	OPNAV FORM 3140-6 (LAND SURFACE)		HYGROTHERMOGRAPH		OPNAV FORM 3140-14 (WINDS ALOFT)
	OPNAV FORM 3140-8 (SHIP SURFACE)	X	SEMI-AUTO. MET. STATION		ANGULAR TAPES
	OPNAV FORM 3140-11 (PILOT REPORTS)	X	WIND		DOD WPC 9-31 (ADIABATIC CHARTS)
		X	BAROGRAPH		RECORDER RECORDS
					RECORDER CALIBRATION
					RADIOSONDE CALIBRATION CHARTS

A

TOTAL NUMBER OF OBSERVATIONS

NO.	WINDS ALOFT	NO.	UPPER AIR	RADIOSONDE ELEMENTS AND COMPUTERS USED WITH ABOVE RECORDS (TYPE DESIGNATION)
	0000 GCT		0000 GCT	THERMISTOR
	0600 GCT		0600 GCT	TEMP. COMPUTER
	1200 GCT		1200 GCT	HYGRISTER
	1800 GCT		1800 GCT	HUMIDITY COMPUTER
	OTHER		OTHER	OTHER

REMARKS

B

THE METEOROLOGICAL RECORDS FORWARDED HEREWITH HAVE BEEN CHECKED FOR ACCURACY, COMPLETENESS AND LEGIBILITY IN ACCORDANCE WITH THE MANUAL OF NAVAL WEATHER SERVICE COMMAND AND ARE PACKAGED ACCORDING TO THE INSTRUCTIONS ON THE REVERSE OF THIS FORM.

C

SUBMITTED (SIGNATURE) H. O. Moore	DATE OF TRANSMITTAL	APPROVED (SIGNATURE) R C Husted
H. O. MOORE, AGC, USN	1 AUGUST 1970	R. C. HUSTED, CDR, USN

APPENDIX XV

METEOROLOGICAL STATION DESCRIPTION AND INSTRUMENTATION REPORT (NWSC FORM 3140/5)

NWSC FORM 3140/5
FORMERLY OPNAV 3140-10
S/N-0108-000-0000

U.S. NAVAL WEATHER SERVICE COMMAND
METEOROLOGICAL STATION REPORT
DESCRIPTION AND INSTRUMENTATION

A

FROM: (ACTIVITY AND MAILING ADDRESS)
Officer-in-Charge
NWS Environmental Detachment
NAS, Memphis, Tennessee 38115

TO: OFFICER IN CHARGE
NAVAL WEATHER SERVICE
ENVIRONMENTAL DETACHMENT
NWRC, FEDERAL BUILDING
ASHEVILLE, NORTH CAROLINA
28801

REASON FOR SUBMISSION
☒ ANNUAL
☐ NEW LOCATION
☐ STATION RELOCATED
☐ INSTRUMENTS RELOCATED
☐ CORRECTION OF DATUM

B

LATITUDE 35 ° 21 ' LONGITUDE 89 ° 52 ' WMO # 334
LST 90 th MERIDIAN CALL LETTERS NQA
HOURS TO CONVERT TO GMT: ADD 6 SUBTRACT

ELEVATIONS AND DATES ESTABLISHED (DEFS. ON REVERSE)		FEET (MSL)	DATE
GROUND	H	300	8/31/42
FIELD	H_a	322	8/31/42
BAROMETER	H_s	295	8/31/42

C

I - IN USE
S - STANDBY
o - NONE

		TYPE	HT. ABV GRND (FT) (SHIPS ABV SEA)	LOCATION	NEAREST OBSTRUCTION	DIST.& DIR. TO OBSTN	HT. OF OBSTN ABV INSTR	DATE COMM. PRESENT EXPOSURE
x	BAROMETER (MERCURIAL)	Fortin	4	Weather Service Office				1/68
x	BAROMETER (ANEROID)	ML-448/UM	4	Weather Service Office				12/60
x	BAROGRAPH	ML-3	4	Weather Service Office				12/60
x	THERMOSCREEN	Cotton Region	3	693' NE of Operations Bldg.	Operations Bldg.	693'SW	50'	7/68
x	STANDARD AIR THERM.	Liquid in glass	3'6"	In Thermoscreen				
x	MAX & MIN AIR THERM.	"	3'6"	In Thermoscreen				
0	HYGROTHERMOGRAPH							
x	PSYCHROMETER	ML-450 A/UM	3	In Thermoscreen				
x	WIND MEASURING EQUIP.	AN/UMQ-5	8	See Section "D"				4/62
x	WIND RECORDER	AN/UMQ-5C	7	Weather Service Office				4/61
x	SEMI-AUTO. MET. STATION	GMQ-14A	5	Weather Service Office				12/60
x	CEILING LIGHT	ML-121	2	4' SE of Thermoscreen	Operations Bldg.	693'SW	50'	7/63
x	CLOUD HEIGHT SET	GMQ-13B	4	See Section "D"				7/60
x	THEODOLITE	Shore type	55'	On top of Operations Bldg.	Control Tower	45' SW	15'	8/42
x	TRANSMISSOMETER	GMQ-10C	4	See Section "D"				12/60
0	RADAR							
0	RADIOSONDE/RAWINSONDE SET							

RELEASE POINT HT MSL 300 INSTRUMENT SHELTER FLOOR HT MSL 3 WHERE PEN SET HT MSL NA

D

DESCRIPTION OF STATION EXPOSURE AND GENERAL REMARKS (CONTINUE ON REVERSE)

The terrain in the immediate vicinity is of the low rolling type. The Mississippi River is approximately eight miles west of the Naval Air Station and is bordered by broad alluvial bottoms from which rise undulating and elevated plains.

The automatic Rain-gage portion of the AN/GMQ-14A is located atop the west wing of building N-2, which is a two story structure.

The wind measuring set AN/UMQ-5C is installed atop a 8 foot mast in a grassy plot bearing 350° from building N-2 at a distance of 1,550 feet. The mast is 530 feet north of the center line of runway 9-27, 450 feet bearing 230° from the center line of runway 14-32.

The detector unit of the Cloud Height Set AN/GMQ-13B is located on a grassy plot 1,300 feet southwest from the south end of runway 3 and 500 feet parallel to the center line of runway 3.

The AN/GMQ-10C Transmissometer projector and receiver are located on a grassy plot 500 feet northwest from the south end of runway 3 and 500 feet parallel to the center line of runway 3. The detector is orientated 10° from parallel, and north of the projector.

E

SUBMITTED (SIGNATURE)	DATE OF TRANSMITTAL	APPROVED (SIGNATURE)
F.H. SAVAGE JR., MET. TECH.	1 January 1971	LT L.J. SCHEIWER, USN

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AEROGRAPHER'S MATE 3 & 2

NAVEDTRA 10363-E

Prepared by the Naval Education and Training Program Development
Center, Pensacola, Florida

Your NRCC contains a set of assignments and self-scoring answer sheets (packaged separately). The Rate Training Manual, Aerographer's Mate 3 & 2, NAVEDTRA 10363-E , is your textbook for the NRCC. If an errata sheet comes with the NRCC, make all indicated changes or corrections. Do not change or correct the textbook or assignments in any other way.

HOW TO COMPLETE THIS COURSE SUCCESSFULLY

Study the textbook pages given at the beginning of each assignment before trying to answer the items, Pay attention to tables and illustrations as they contain a lot of information. Making your own drawings can help you understand the subject matter. Also, read the learning objectives that precede the sets of items. The learning objectives and items are based on the subject matter or study material in the textbook. The objectives tell you what you should be able to do by studying assigned textual material and answering the items.

At this point you should be ready to answer the items in the assignment. Read each item carefully. Select the BEST ANSWER for each item, consulting your textbook when necessary. Be sure to select the BEST ANSWER from the subject matter in the textbook. You may discuss difficult points in the course with others. However, the answer you select must be your own. Use only the self-scoring answer sheet designated for your assignment. Follow the scoring directions given on the answer sheet itself and elsewhere in this course.

Your NRCC will be administered by your command or, in the case of small commands, by the Naval Education and Training Program Development Center. No matter who administers your course you can complete it successfully by earning grades that average 3.2 or higher. If you are on active duty, the average of your grades in all assignments must be at least 3.2. If you are NOT on active duty, the average of your grades in all assignments of each creditable unit must be at least 3.2. The unit breakdown of the course, if any, is shown later under Naval Reserve Retirement Credit.

WHEN YOUR COURSE IS ADMINISTERED BY LOCAL COMMAND

As soon as you have finished an assignment, submit the completed self-scoring answer sheet to the officer designated to administer it. He will check the accuracy of your score and discuss with you the items that you do not understand. You may wish to record your score on the assignment itself since the self-scoring answer sheet is not returned.

If you are completing this NRCC to become eligible to take the fleetwide advancement examination, follow a schedule that will enable you to complete all assignments in time. Your schedule should call for the completion of at least one assignment per month.

Although you complete the course successfully, the Naval Education and Training Program Development Center will not issue you a letter of satisfactory completion. Your command will make a note in your service record, giving you credit for your work.

WHEN YOUR COURSE IS ADMINISTERED BY THE NAVAL EDUCATION AND TRAINING PROGRAM DEVELOPMENT CENTER

After finishing an assignment, go on to the next. Retain each completed self-scoring answer sheet until you finish all the assignments in a unit (or in the course if it is not divided into units). Using the envelopes provided, mail your self-scored answer sheets to the Naval Education and Training Program Development Center where the scores will be verified and recorded. Make sure all blanks at the top of each answer sheet are filled in. Unless you furnish all the information required, it will be impossible to give you credit for your work. You may wish to record your scores on the assignments since the self-scoring answer sheets are not returned.

The Naval Education and Training Program Development Center will issue a letter of satisfactory completion to certify successful completion of the course (or a creditable unit of the course). To receive a course-completion letter, follow the directions given on the course-completion form in the back of this NRCC.

You may keep the textbook and assignments for this course. Return them only in the event you disenroll from the course or otherwise fail to complete the course. Directions for returning the textbook and assignments are given on the book-return form in the back of this NRCC.

PREPARING FOR YOUR ADVANCEMENT EXAMINATION

Your examination for advancement is based on the Manual of Navy Enlisted Manpower and Personnel Classification and Occupational Standards (NAVPERS 18068-D). The sources of questions in this examination are given in the Bibliography for Advancement Study (NAVEDTRA 10052). Since your NRCC and textbook are among the sources listed in this bibliography, be sure to study both in preparing to take your advancement examination. The standards for your rating may have changed since your course and textbook were printed, so refer to the latest editions of NAVPERS 18068-D and NAVEDTRA 10052.

NAVAL RESERVE RETIREMENT CREDIT

This course is evaluated at 24 Naval Reserve retirement points, which will be credited in units as follows: Unit 1: 12 points upon satisfactory completion of Assignments 1 through 6; and, Unit 2: 12 points upon satisfactory completion of Assignments 7 through 12. These points are creditable to personnel, eligible to receive them under current directives governing retirement of Naval Reserve personnel. Naval Reserve retirement credit will not be given for this course if the student has previously received retirement credit for any Aerographer's Mate 3 & 2, NRCC or ECC.

COURSE OBJECTIVE

The objective of this course is to provide the Aerographer's Mate with information on the enlisted rating structure, rating requirements, procedures for advancement, and sources of information; operation, care, use, and maintenance of pressure, wind, temperature, humidity, precipitation, cloud, and visibility equipment, and recording procedures; the function, operation, care, and use of radar and satellite equipment; operation, care, use, and operational procedures for communications, office, and specialized meteorological equipment; watch routines including observational programs, procedures, and code systems, plotting and analyzing surface, upper air, oceanographic, and specialized weather charts, the filing and display of weather data; the fundamentals of oceanography; administration, publication, and supply; basic meteorology including air masses and fronts, circulation patterns, and meteorological elements.

While working on this nonresident career course, you may refer freely to the text. You may seek advice and instruction from others on problems arising in the course, but the solutions submitted must be the result of your own work and decisions. You are prohibited from referring to or copying the solutions of others, or giving completed solutions to anyone else taking the same course.

Naval nonresident career courses may include a variety of items -- multiple-choice, true-false, matching, etc. The items are not grouped by type; regardless of type, they are presented in the same general sequence as the textbook material upon which they are based. This presentation is designed to preserve continuity of thought, permitting step-by-step development of ideas. Some courses use many types of items, others only a few. The student can readily identify the type of each item (and the action required of him) through inspection of the samples given below.

MULTIPLE-CHOICE ITEMS

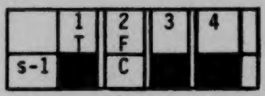
Each item contains several alternatives, one of which provides the best answer to the item. Select the best alternative and erase the appropriate box on the answer sheet.

SAMPLE

s-1. The first person to be appointed Secretary of Defense under the National Security Act of 1947 was

1. George Marshall
2. James Forrestal
3. Chester Nimitz
4. William Halsey

The erasure of a correct answer is indicated in this way on the answer sheet:



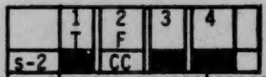
TRUE-FALSE ITEMS

Determine if the statement is true or false. If any part of the statement is false the statement is to be considered false. Erase the appropriate box on the answer sheet as indicated below.

SAMPLE

s-2. Any naval officer is authorized to correspond officially with a bureau of the Navy Department without his commanding officer's endorsement.

The erasure of a correct answer is also indicated in this way on the answer sheet:



MATCHING ITEMS

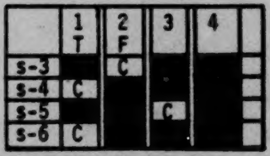
Each set of items consists of two columns, each listing words, phrases or sentences. The task is to select the item in column B which is the best match for the item in column A that is being considered. Specific instructions are given with each set of items. Select the numbers identifying the answers and erase the appropriate boxes on the answer sheet.

SAMPLE

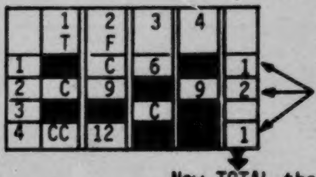
In items s-3 through s-6, match the name of the shipboard officer in column A by selecting from column B the name of the department in which the officer functions.

A. Officers	B. Departments
s-3. Damage Control Assistant	1. Operations Department
s-4. CIC Officer	2. Engineering Department
s-5. Assistant for Disbursing	3. Supply Department
s-6. Communications Officer	

The erasure of a correct answer is indicated in this way on the answer sheet:



How To Score Your Immediate Knowledge of Results (IKOR) Answer Sheets



Total the number of incorrect erasures (those that show page numbers) for each item and place in the blank space at the end of each item.

Sample only

Number of boxes erased incorrectly	0-2	3-7	8-
Your score	4.0	[✓ 3.9]	3.8

Now TOTAL the column(s) of incorrect erasures and find your score in the Table at the bottom of EACH answer sheet.

NOTICE: If, on erasing, a page number appears, review text (starting on that page) and erase again until "C", "CC", or "CCC" appears. For courses administered by the Center, the maximum number of points (or incorrect erasures) will be deducted from each item which does NOT have a "C", "CC", or "CCC" uncovered (i.e., 3 pts. for four choice items, 2 pts. for three choice items, and 1 pt. for T/F items).

Assignment 1

Aerographer's Mate Rating and Pressure Equipment

Text: Pages 1 - 32

In this course you will demonstrate that learning has taken place by correctly answering training items. The mere physical act of indicating a choice on an answer sheet is not in itself important; it is the mental achievement, in whatever form it may take, prior to the physical act that is important and toward which nonresident career course learning objectives are directed. The selection of the correct choice for a course training item indicates that you have fulfilled, at least in part, the stated objective(s).

The accomplishment of certain objectives, for example, a physical act such as drafting a memo, cannot readily be determined by means of objective type course items; however, you can demonstrate by means of answers to training items that you have acquired the requisite knowledge to perform the physical act. The accomplishment of certain other learning objectives, for example, the mental acts of comparing, recognizing, evaluating, choosing, selecting, etc., may be readily demonstrated in a course by indicating the correct answers to training items.

The comprehensive objective for this course has already been given. It states the purpose of the course in terms of what you will be able to do as you complete the course.

The detailed objectives in each assignment state what you should accomplish as you progress through the course. They may appear singly or in clusters of closely related objectives, as appropriate; they are followed by items which will enable you to indicate your accomplishment.

All objectives in this course are learning objectives and items are teaching items. They point out important things, they assist in learning, and they should enable you to do a better job for the Navy.

This self-study course is only one part of the total Navy training program; by its very nature it can take you only part of the way to a training goal. Practical experience, schools, selected reading, and the desire to accomplish are also necessary to round out a fully meaningful training program.

Learning Objective: Identify the general contents of chapter 1 of the text, distinguish between general and service ratings, and between the terms rate and rating.

1-1. In what manual are the minimum professional qualifications for advancement in all ratings listed?
   1. NAVPERS 10056-D
   2. NAVPERS 18068 (Series)
   3. NAVEDTRA 10052-W
   4. NAVEDTRA 10315-B

1-2. What do the qualifications of a general rating reflect?
   1. Civilian skills identified with a peacetime Navy
   2. Civilian skills identified with a wartime Navy
   3. Broad occupational fields of related duties and functions
   4. Subdivisions or specialties within broad occupation fields

1-3. What term identifies personnel occupationally by pay grade?
   1. Rate
   2. Rating
   3. Assignment
   4. Billet

1-4. The rating structure for naval enlisted personnel in the AG rating provides for what type(s) of ratings?
1. Service ratings only
2. General ratings only
3. General and service ratings only
4. General, service, and emergency ratings

1-5. The specific duties which you will perform at your assigned activity will depend largely upon the
1. Navy schools you have attended
2. individual capabilities of the AGs assigned to your activity
3. type of activity to which you are assigned
4. type and number of correspondence courses you have completed

1-6. An AG3 must have technical knowledge of all but which of the following?
1. The general characteristics of basic frontal systems
2. The application of basic laws of motion
3. The primary, secondary, and tertiary circulations of the atmosphere
4. The principles and procedures of visual upper wind observations

---

Learning Objective: Recognize advantages of, procedures for, and materials to be studied in preparation for advancement, and principles of leadership.

1-7. As an AG advances, his success is judged increasingly in terms of the
1. amount of work he does
2. amount of efficient work his men do
3. number of different billets he has held
4. neatness and orderliness of the work areas for which he is responsible

1-8. Which of the following publications should the AG striker study in order to learn the leadership qualities expected of him when he advances to a petty officer rate?
1. Aerographer's Mate 3 & 2, NAVEDTRA 10363-E
2. Bibliography for Advancement Study, NAVEDTRA 10052 (Series)
3. Military Requirements for Petty Officer 3 & 2, NAVEDTRA 10056 (Series)
4. List of Training Manuals and Correspondence Courses, NAVEDTRA 10061 (Series)

1-9. In addition to receiving an increased amount of pay, the personal benefits realized from an advancement should include which of the following?
1. A feeling of accomplishment only
2. Greater interest in the jobs to be done only
3. Increased respect from both supervisors and subordinates only
4. A feeling of accomplishment, greater interest in the jobs to be done, and increased respect from both supervisors and subordinates

1-10. Which of the following systems allows a command to evaluate the overall abilities of an individual in a day-to-day work situation?
1. Record of Practical Factors
2. Personnel Qualification Standards
3. Personnel Advancement Requirement Program
4. Bibliography for Advancement

1-11. Which section(s) of the NAVPERS 1414/4 contains a checkoff list of task statements?
1. I and III
2. I only
3. II only
4. III only

1-12. The knowledge and skills required of a particular rating concerning a SPECIFIC weapons system are analyzed in the
1. applicable Rate Training Manual
2. Personnel Qualifications Standards (PQS)
3. Manual of Qualifications for Advancement
4. Record of Practical Factors

1-13. Guidelines for self-study of fundamentals normally taught in Preparatory, Fundamentals, and Class-A schools are outlined in which PQS section?
1. Theory--100 Series
2. Systems--200 Series
3. Watch stations--300 Series
4. Qualifications cards--400 Series

1-14. Which section of the Personnel Qualifications Standards contain items designed to determine if an individual has the abilities necessary to cope with the maintenance of a system?
1. Theory--100 Series
2. Systems--200 Series
3. Watch stations--300 Series
4. Qualifications cards--400 Series

1-15. What does a letter following the NAVEDTRA number assigned to the Bibliography for Advancement Study, NAVEDTRA 10052 (Series), indicate?

1. The BUPERS Notice that supersedes the publication
2. A revision to the publication
3. A supplement to the publication
4. The effective date of the publication

1-16. Your textbook states that you should study the references which are recommended as well as those that are mandatory in the study bibliography in NAVEDTRA 10052 because

1. completion of these courses is necessary for being recommended for the next rate
2. these references may furnish source material for some questions in the written examination for advancement
3. you cannot be advanced without being examined on these references
4. these references are for your knowledge only and are not to be used for advancement items

1-17. Before being eligible to take the Navy-wide advancement examination for a rate, the AG must complete those training manuals marked with an asterisk (*) in which publication?

1. The "Quals" Manual, NAVPERS 18068 (Series)
2. List of Training Manuals and Correspondence Courses, NAVEDTRA 10061 (Series)
3. Training Publications for Advancement, NAVEDTRA 10052 (Series)
4. Manual of Enlisted Classifications, NAVPERS 15106 (Series)

1-18. What are the general qualifications which all enlisted personnel are expected to demonstrate as a minimum for advancement at all rate levels?

1. Knowledge factors
2. Practical factors
3. Military standards/requirements
4. Professional qualifications

Learning Objectives: Identify types of training manuals and how they are numbered.

1-19. What kind of training manual is Aerographer's Mate 3 & 2, NAVEDTRA 10363-E?

1. Basic
2. Rating
3. General
4. Subject matter

1-20. The word basic, as used in Rate Training Manual titles, has which of the following meanings relative to the material in the basic manual?

1. The material is common to several Navy ratings
2. The material should be studied by all Navy personnel
3. The material is simple and fundamental enough to be understood by beginners
4. The material is basic or fundamental to the rating from which the title is derived

1-21. NAVEDTRA 10061 (Series) may help you in planning your study program for advancement because it lists the

1. recommended and required rate training manuals
2. correspondence courses and training manuals
3. minimum requirements for advancement
4. recommended correspondence courses

1-22. The fundamental purpose of a Rate Training Manual is to

1. aid personnel to advance
2. offer advanced study to graduates of Navy schools
3. teach specific equipments to personnel in specific ratings
4. cover the professional and military aspects of specific rates

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Learning Objective: Indicate recommended ways to study a training manual.

1-23. What is the first step to take prior to beginning study of a Rate Training Manual?

1. Read the chapter headings
2. Outline the entire manual
3. Familiarize yourself with the entire manual
4. Prepare a list of questions to be answered as study progresses

1-24. The reasons why suggestions 4 and 7 are included in the list of study suggestions given in your textbook is that in following them you
1. write an outline of the manual which will be a valuable reference for future study
2. are able to peg each subject to an individual qualification given in the "Quals" Manual
3. are able to separate the military qualifications from the professional qualifications in the textbook
4. familiarize yourself with the aims and contents of the manual and relate the subject areas to your past experiences thereby creating an excellent learning situation

1-25. When must you successfully complete the E-4 or E-5 military leadership examination?
1. At the same time the professional examination is administered
2. Prior to participating in the professional examination
3. After successfully completing the professional examination
4. At any time, as appropriate

1-26. Which of the following is NOT a factor in determining the final multiple score?
1. Time in rate
2. Annual evaluation
3. Selection board
4. Time in service

1-27. Which of the following is NOT a purpose of the Subject-Matter Section Identification Sheet?
1. It represents the subject-matter sections of the examination
2. It enables you to immediately analyze your relative standing with others who took the examination
3. It is used for purposes of command review
4. It indicates the occupational standards used to support the examination questions

1-28. The Profile Analysis Form is used in conjunction with the
1. Subject-Matter Section Identification Sheet
2. Rate Training Manual
3. Record of Practical Factors
4. Bibliography for Advancement Study

1-29. Refer to figure 1-4. Section 3 of the Profile Analysis Form indicates the candidates relative standing was in the
1. upper 30%
2. lower 40%
3. lower 30%
4. upper 40%

1-30. The Profile Analysis Form provides all but which of the following?
1. Examination status
2. Final multiple
3. Advancement date
4. Minimum multiple required for advancement

Learning Objective: Recognize observation and computational procedures for determining pressure measurements to be entered on the various meteorological forms.

1-31. Which of the following is a theoretical reduction of station pressure used to give all stations a standard reference level?
1. Pressure altitude
2. Altimeter setting
3. Sea level pressure
4. Atmospheric pressure

1-32. What is the problem in reading the aneroid barometer that causes the pressure reading to be higher or lower than the correct reading?
1. Angle of parallax
2. Angle of incidence
3. Latitude corrections
4. Temperature corrections

1-33. How is the observed barometric pressure in inches determined on the mercurial barometer?
1. By adding the figures on the fixed and vernier scales
2. By reducing the figure on the fixed scale by a constant correction factor
3. By increasing the figure on the fixed scale by a constant additive factor
4. By subtracting the figure on the vernier scale from that on the fixed scale

1-34. For a more complete description on determining pressure computations, one should refer to which FMH publications?
1. FMH-1 and FMH-2
2. FMH-8 and FMH-2
3. FMH-8 and FMH-7
4. FMH-1 and FMH-8

1-35. Which of the following statements concerning the table of "r" values is correct?
1. An "r" table may be used at all stations
2. The values found in the "r" table are a ratio of station pressure to temperature
3. The table is used in conjunction with the meteorological computer, CP-402/UM, for the determination of sea level pressure
4. By algebraically adding the appropriate value from the "r" table to sea level pressure, station pressure may be computed

1-36. Altimeter settings are computed for all observations EXCEPT for
1. single element special observations
2. special observations
3. local observations
4. record special observations

1-37. The net pressure change in a specified time and the characteristics of the change during that specified time are generally determined only at stations equipped with a/an
1. CP-402/UM
2. AN/GMQ-14( )
3. microbarograph
4. hygrothermograph

1-38. What is indicated if the entry in column 5 of the MF1-10 form is 985?
1. A station pressure of 29.985 in.
2. A sea level pressure of 998.5 mb
3. An altimeter setting of 29.985 in.
4. A sea level pressure of 1,099.85 mb

1-39. If the altimeter setting of a station was determined to be 29.97 inches from pressure instruments NOT periodically checked with a mercurial barometer, how is this information to be entered in column 12 of an MF1-10 form?
1. 997E
2. E997
3. E99.7
4. 99.7E

1-40. How is the sea level pressure recorded in column 9 on the MF1-11 form determined?
1. By adding a constant-pressure reduction factor to the station pressure entered in column 23
2. By converting the station pressure entered in column 23 to millibars and subtracting 0.037 mb
3. By observing a mercurial barometer which has been compared to an aneroid barometer
4. By subtracting 0.001 inch from the station pressure entered in column 23

1-41. When the roll of a ship causes the indicator on the aneroid barometer to oscillate, how, if at all, should the observer obtain the station pressure?
1. By taking the higher pressure position on the indicator
2. By taking the mean pressure position on the indicator
3. By taking the lower pressure position on the indicator
4. No pressure reading should be taken

1-42. A barometer has been installed and operationally accepted as reliable in your weather office. At 6-hour intervals on the same day of each week comparisons are made and entered on MF1-13 in accordance with instructions on the reverse side of the form. How many comparisons are made?
1. Five
2. Two
3. Three
4. Four

Learning Objective: Relative to barographs and barometers, recognize operational characteristics and procedures, construction features, operating features, component functions, and maintenance procedures.

1-43. A marine barograph is often referred to as a microbarograph because of its
1. reduced scale, high sensitivity, and remote recording features
2. high sensitivity, magnified scale, and accurate temperature compensation
3. magnified scale, widely calibrated range, and precision maintenance ability
4. widely calibrated range, accurate temperature compensation, and remote recording features

1-44. What part of the pen shaft assembly of a marine barograph prevents pitch, roll, and vibration of the ship from causing excessive variations from the true reading?
1. The case mounting
2. The damping cylinder
3. The range adjustment
4. The linearity adjustment

1-45. The chart used with the marine barograph will record barometric pressure over a period of how many hours?
1. 192 hr
2. 132 hr
3. 108 hr
4. 96 hr

1-46. What is the normal operating accuracy of the marine barograph with respect to true pressure?
1. ±0.3 mb
2. ±0.5 mb
3. ±0.67 mb
4. ±0.68 mb

1-47. You must take the following steps when changing the chart and winding the clock of a marine barograph. What is the correct order of these steps?
A. Wind the clock
B. Place the new chart on the cylinder
C. Set the pen to the correct time by rotating the cylinder
D. Disengage the pen from the chart and remove the cylinder
E. Carefully install the cylinder ensuring that the anti-backlash gear teeth engage
F. Check the ink level in the pen and lower the pen to the chart
1. D,B,A,E,C,F
2. D,A,B,E,C,F
3. A,D,E,B,C,F
4. A,D,B,E,C,F

1-48. What is the cause for a trace on a marine barograph chart that is weak in color?
1. The point of the pen has become dull or bent
2. Dust has accumulated on the pen point
3. The instrument ink has become diluted by absorbing moisture
4. The fluid in the dashpot has dropped to a low level

1-49. On what principle is the operation of the Fortin mercurial barometer based?
1. The difference in coefficients of linear expansion of mercury and glass causes the height of the mercury column to vary with air pressure
2. A vacuum presses down on the mercury in the column with a force equal to the force of air on the mercury in the cistern
3. Air presses down on the mercury in the cistern with a force equal to the height of the mercury column
4. The change in the shape of a mercurial cell is proportional to the change in air pressure

1-50. When is the adjusting screw of the Fortin barometer utilized?
1. After each reading of the barometer
2. Before each observation with the barometer
3. Immediately before the barometer is installed
4. Immediately after installation of the barometer

1-51. Which of the following statements is correct regarding the kid leather bag of the Fortin barometer?
1. It will not prevent mercury leakage
2. It prevents air from entering the cistern area
3. It assures that the outside air pressure and the cistern air pressure are equal
4. It must remain in the same position to be effective as a shock absorber for the instrument

1-52. The Fortin barometer can be read, without interpolation, to the nearest
1. 0.002 in. on the vernier scale
2. 0.002 in. on the stationary scale
3. 0.050 in. on the vernier scale
4. 0.050 in. on the stationary scale

1-53. What maintenance may the Aerographer's Mate perform on the Fortin barometer?
1. Shine the scales with a high grade, commerical polish
2. Replace broken glass tubes
3. Change damaged thermometers
4. Replace mercury lost due to leakage

1-54. How do reliability and convenience of aneroid barometers compare with reliability and convenience of mercurial barometers?
1. Aneroid barometers are less accurate and more difficult to handle than mercurial barometers
2. Aneroid barometers are more accurate and more difficult to handle than mercurial barometers
3. Aneroid barometers are less accurate and easier to handle than mercurial barometers
4. Aneroid barometers are more accurate and easier to handle than mercurial barometers

1-55. Which of the following is employed in an aneroid barometer to detect variations in atmospheric pressure?
1. Alcohol
2. An evacuated metal cell
3. Mercury
4. Water

1-56. Which statement describes the corrections that must be made to aneroid and mercurial barometers?
1. Mercurial barometers require no corrections for temperature or effect of gravity, but aneroid barometers require correction for the effect of gravity
2. Aneroid barometers require temperature correction only, but mercurial barometers require corrections for temperature and effect of gravity
3. Mercurial barometers require correction for the effect of gravity only, but aneroid barometers require no corrections for temperature or the effect of gravity
4. Aneroid barometers require no corrections for temperature or effect of gravity, but mercurial barometers require temperature correction

1-57. The screw located at the base of the Sylphon cell of a precision aneroid barometer is used to
1. make corrections for gravity
2. make corrections for temperature
3. adjust the range of the barometer
4. adjust the barometer to the correct readings

1-58. What are the sequential procedures followed when a precision aneroid barometer is adjusted to a zero correction?
1. Take a series of comparative readings between the mercurial and aneroid barometers, log the difference and compute the algebraic difference; and adjust the instrument by removing one-half of this value in a series of adjustments until a zero correction is attained
2. Take a series of comparative readings between the mercurial and aneroid barometers, log the differences and compute the algebraic difference; and adjust the instrument to an apparent zero correction using the algebraic difference. Repeat these steps until a zero correction is attained
3. Adjust the instrument by removing one-half of the apparent error, remove the linkage lag by tapping the case, and determine the remaining error from a comparative mercurial barometer reading. Repeat these steps until a correction of zero is attained
4. Adjust the instrument to an apparent zero correction, remove the linkage lag by tapping the case, and determine the remaining error from a comparative mercurial barometer reading. Repeat these steps until a correction of zero is attained

1-59. When, if ever, should the aneroid barometer (ML-448/UM) be lubricated?
1. Never
2. Quarterly
3. Semiannually
4. Annually

Learning Objective: Relative to altimeters, recognize types, uses, and operational characteristics and procedures.

1-60. Which of the following is NOT a basic type of altimeter in general use today?
1. Barometric pressure transducer
2. Radar
3. Radio
4. Pressure

1-61. Refer to figure 2-9 in your text. If the pressure at New Orleans was 1029 mb vice 1009 mb what would be your actual altitude and indicated altitude assuming NO change in altimeter setting?
1. Actual altitude would be 800 feet and indicated altitude 500 feet
2. Actual altitude would be 500 feet and indicated altitude 800 feet
3. Actual altitude would be 500 feet and indicated altitude 500 feet
4. Actual altitude would be 1,000 feet and indicated altitude 800 feet

1-62. Which of the following statements comparing flight level with true altitude is correct?
1. A flight level would be lower than the true altitude when the air temperature is above standard air temperature
2. A flight level would be higher than the true altitude when the air temperature is less than the standard air temperature
3. A flight level and the true altitude would correspond only when standard atmosphere conditions are present
4. A flight level would never be the same as true altitude

1-63. Radio altimeters operate better over water than they do over land because the water
1. area is flatter than land
2. conducts sound better than land
3. reflects sound better than land
4. scatters sound better than land

Learning Objective: Recognize pressure computers, their operation, and maintenance requirements.

1-64. The Density Altitude Computer CP-718/UM, although primarily designed to determine atmospheric density, can also be used to determine

1. vapor pressure and "r" factors
2. vapor pressure and specific humidity
3. specific humidity and "r" factors
4. specific humidity and station pressure

1-65. When the plastic computers used at the various Naval Weather Service units are cleaned, only a soft cloth and which of the following should be used?

1. Alcohol
2. Ditto fluid
3. Plastic wax
4. Soap and water

Assignment 2

Temperature, Humidity, and Precipitation Equipment

Text: Pages 33 - 69

Learning Objective: Recognize characteristics of wind, and methods and procedures used for obtaining and recording wind observations.

2-1. A sudden increase in the wind speed of at least 15 knots and substained at 20 knots or more for at least 1 minute defines a
1. gust
2. peak gust
3. squall
4. downdraft

2-2. Which of the following characteristics of wind may be included in wind speed?
1. Squalls only
2. Gustiness only
3. Wind shifts only
4. Squalls, gustiness, and wind shifts

2-3. Cold frontal passages may be indicated by
1. wind shifts
2. pressure falls
3. humidity increases
4. temperature rises

2-4. Wind direction is considered to be variable when it fluctuates by how many degrees?
1. 30° or more
2. 45° or more
3. 50° or more
4. 60° or more

2-5. For observational purposes, how long should you observe wind direction and speed?
1. One-minute average
2. Five-minute average
3. Ten-minute average
4. Instantaneously

2-6. Refer to Appendix VI in your text. Assuming that wind-measuring instruments are NOT availiable, a wide range of wind speeds can best be estimated by careful observation of the
1. smoke drift from high stacks
2. effects on trees and leaves
3. structural damage to buildings
4. whistling sounds emitted by telephone wires

2-7. A wind of 105 knots from 250° should be encoded and entered in columns 9 and 10 of an MF1-10 form as
1. 25 05
2. 30 05
3. 50 05
4. 75 05

2-8. What does the notation "Q45" in column 11 of an MF1-10 form mean?
1. Gusts have been observed during the preceding 45 minutes
2. Squalls have been observed during the preceding 45 minutes
3. Squalls, with peak speeds of 45 knots, have been observed during the preceding 10 minutes
4. Gusts, with peak speeds of 45 knots, have been observed during the preceding 10 minutes

2-9. When will peak gust and squall data be reported on MF1-10 surface observation forms?
1. When either an AN/UMQ-5 or Type B3 wind equipment is available
2. When data from a RD-108 wind recorder is available
3. When either an AN/GMQ-29 or AN/GMQ-14 weather station is available
4. When any type of wind equipment is utilized

2-10. Which of the following is a proper windshift entry in column 13 of an MF1-10 form?
1. WSHFT 1530
2. WSHFT 1530E
3. WSHFT 1530Z
4. WSHFT 1530 GMT

2-11. If, at the time of the observation, there was a 15-knot true wind from the west with peak gusts of 22 knots, data for columns 12, 13, and 14 of the MF1-11 will be entered, respectively, as
1. 090 15G 22
2. 270 15 G22
3. 15 270 Q22
4. G22 15 090

2-12. How may the true wind direction and speed be determined for entry on the MF1-11 form?
1. By estimating only
2. By using the CP-264U computer only
3. By using the plotting board method only
4. By using the plotting board and the CP-264U computer or estimating

2-13. Wind recorder charts are changed at intermediate times as necessary to prevent loss of record and always on the first day of the
1. week at 0000 GMT
2. month at 0000 GMT
3. week at 0000 LST
4. month at 0000 LST

Learning Objective: Recognize operating and maintenance practices associated with the AN/PMQ-3( ) Wind Measuring Set.

2-14. The trigger on the handle of the Wind Measuring Set AN/PMQ-3( ) is used to lock the
1. vane on a given setting
2. voltmeter on the 0- to 15-knot scale
3. voltmeter on the 0- to 60-knot scale
4. cylindrical turbine when the set is not in use

2-15. Damage will first occur to the pointer of the AN/PMQ-3 if the range selection trigger is depressed when the wind speed exceeds the maximum of
1. 16 kn
2. 15 kn
3. 10 kn
4. 5 kn

2-16. Refer to Table 3-2 in your text. If the pointer of the wind speed indicator of the AN/PMQ-3( ) does NOT rest on zero when the turbine is stationary, what should be done?
1. The switch should be checked
2. The indicator should be replaced
3. The transmitter should be replaced
4. An adjustment should be made with the zero adjustment control screw

2-17. The wind speed transmitter of the AN/PMQ-3( ) should be lubricated once every
1. month
2. two months
3. three months
4. six months

Learning Objective: Relative to components of the Wind Measuring Set AN/UMQ-5( ), indicate minimum acceptable combinations, operational features, model differences, and applicable maintenance procedures.

2-18. Refer to figure 3-2 (A through E) in your textbook. The Wind Measuring Set AN/UMQ-5( ) includes which of the following combinations as a minimum?
1. A, B, D, and E
2. A, B, and E
3. A, C, D, and E
4. A, C, and D

2-19. How does the transmitter of the AN/UMQ-5( ) position the wind direction indicator needle?
1. The motion of the impeller drives the needle directly by means of mechanical couplings through links, shafts, and gears
2. The motion of the vane drives the indicator needle directly by means of a hydraulic coupling through a capillary tube
3. The motion of the vane is transmitted to a synchro in the vertical support and a follower synchro in the indicator positions the needle mechanically
4. The motion of the impeller drives a tachometer-magneto whose output is measured by a voltmeter which is mechanically attached to a needle in the indicator

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2-20. Which component of the AN/UMQ-5( ) provides a visual indication of wind speeds in two ranges -- 0 to 60 knots and 0 to 120 knots?
1. CP-165( )/UM
2. ID-300( )/UMQ-5
3. ID-586/UMQ-5
4. RD-108( )/UMQ-5

2-21. A mechanism that automatically repositions the pen on the chart is incorporated in which of the following components of the RD-108( )/UMQ-5 recorder?
1. Wind speed
2. Chart drive
3. Wind direction
4. Chart guide pen lift

2-22. Both the wind direction and speed mechanisms of the RD-108( )/UMQ-5 recorder have identical pen and inking systems, and the ink is fed to the pen by
1. capillary action
2. gravity action
3. mechanical action
4. sealed pressure action

2-23. When the chart is moving at the speed for which it was primarily designed, how many hours of past wind speed record can be seen through the plastic window of the AN/UMQ-5( ) recorder case?
1. 1 hour and 12 minutes
2. 2 hours and 20 minutes
3. 4 hours and 40 minutes
4. 7 hours

In items 2-24 through 2-27, select from column B the wind measuring equipment component model which applies to each model difference described in column A.

A. Model differences

2-24. This indicator possess a resistance strip to permit the adjustments needed to use from one to six repeaters

2-25. A pen stop arrangement is incorporated to prevent the pen from catching in the center holes of the chart

2-26. Six repeaters can be used with this model due to its enlarged synchro section

2-27. A built-in relay system in this model accommodates one to six repeaters running from the same transmitter

B. Models

1. ML-400B transmitter
2. ID-300B indicator
3. RD-108B recorder
4. Recorder available with the AN/UMQ-5D

2-28. To prevent the spilling of ink during the filling and insertion of the ink tanks on the RD-108/UMQ-5, they should only be filled
1. one-half full
2. five-eighths full
3. three-fourths full
4. seven-eighths full

2-29. The RD-108( )/UMQ-5 recorder is equipped with chart drive gears which can be changed to drive the chart at any of the following speeds EXCEPT
1. 1 1/2 inches per hour
2. 3 inches per hour
3. 6 inches per hour
4. 12 inches per hour

2-30. When a new replacement pen is properly seated in the penholder and the penpoint does NOT touch the chart, what maintenance procedure should be followed first?
1. The pen should be filled with ink
2. The power supply should be checked
3. The pen element should be rebalanced
4. The pen element should be bent so it touches the chart

2-31. Ink tanks and pens of the RD-108( )UMQ-5 recorder may be installed and removed for servicing when the chart drive is
1. removed only
2. tilted forward only
3. in its operating position only
4. removed, tilted forward, or in its operating position

2-32. When the ink tanks of the RD-108 are cleaned and all the dried ink does NOT come off, they should be soaked in a solution of
1. alcohol
2. turpentine
3. gasoline
4. soap and water

2-33. Which of the following AN/UMQ-5( ) maintenance procedures may be performed by an AG3?
1. Replacing the transmitter impeller
2. Rebalancing the recorder pen element
3. Lubricating the transmitter components
4. Replacing the servo follower in the recorder

Learning Objective: Recognize the ways of determining true winds at sea utilizing the True Computer CP-264/UM and the true wind observing methods.

2-34. Which of the following is NOT a method of checking winds computed on the CP-264/UM True Wind Computer for accuracy?
1. The true direction of the wind is always on the same side of the ship as the apparent direction, but farther from the bow (bow or starboard) than the apparent direction
2. The true speed of the wind is greater than the apparent speed whenever the apparent direction is aft of the beam
3. The true speed of the wind is less than the apparent speed whenever the true direction is forward of the beam
4. The true direction of the wind is always on the opposite side of the ship from the apparent direction, but farther from the bow (port or starboard) than the apparent direction

2-35. Refer to Table 3-3 in your textbook. Small waves, becoming longer with fairly frequent white foam crests, provide an estimated wind of
1. 6 kn
2. 10 kn
3. 14 kn
4. 20 kn

Learning Objective: Recognize the characteristics, nomenclature, maintenance requirements, and procedures for using temperature, humidity, and precipitation measuring instruments; and procedures for computing and recording temperature, humidity, and precipitation observations.

2-36. The temperature, which is defined as the measure of its molecular activity, is measured on an arbitrary scale from that point at which its molecules stop moving. This point is known as
1. absolute zero
2. its boiling point
3. its freezing point
4. zero on whatever thermometer is being used

2-37. When a sling psychrometer is used, the operator must whirl it several times, read both thermometers to the nearest tenth of a degree, and repeat the whirling until the wet-bulb temperature fails to show further decline. The difference between the dry-bulb and wet-bulb temperatures is known as the
1. absolute humidity
2. wet-bulb depression
3. relative humidity
4. dewpoint

2-38. If a sample of air is saturated at a temperature of 52° F, what will be the reading of the sample's dewpoint?
1. Exactly 52° F
2. Between 45° and 52° F
3. Between 52° and 59° F
4. 60° F or above

2-39. Which equipment, if available, is used by the Navy in preference to all other equipments to make the psychrometric observations to be entered in columns 7, 8, 18, 19, and 20 of an MF1-10 form?
1. The rotor psychrometer
2. The remote recording hygrothermometer
3. The psychrometric computer
4. The sling psychrometer

2-40. When a remote recording hygrothermometer is used, Fahrenheit temperature values are read on the
1. left-hand edge of the trace to the nearest degree
2. left-hand edge of the trace to the nearest tenth of a degree
3. right-hand edge of the trace to the nearest degree
4. right-hand edge of the trace to the nearest tenth of a degree

2-41. From the arrangement below, select the correct sequence of steps you perform when operating the Hand Electric Psychrometer ML-450A/UM at temperatures above 50°.

A. Place psychrometer in operating position
B. Saturate wet-bulb wick
C. Turn switch knob counterclockwise
D. Evaluate readings
E. Expose psychrometer to free air for at least 5 minutes
F. Take readings
G. Turn switch knob clockwise

1. A, B, C, E, F, G, D
2. B, A, G, E, F, C, D
3. E, B, A, G, F, C, D
4. G, B, A, E, F, C, D

2-42. When full, the tube of the 4-inch rain gage holds how many inches of rainfall?

1. One inch
2. Two inches
3. Three inches
4. Four inches

2-43. The unmelted depth of solid precipitation that has fallen during the past six hours is entered on MF1-10 to the nearest

1. 0.01 in
2. 0.10 in
3. 0.50 in
4. 1.00 in

2-44. Even though the precipitation amount to be entered in column 44 of an MF1-10B form is the total precipitation for the indicated period to 0.01 of an inch, what is entered if only a trace of precipitation occurs?

1. T
2. Trace
3. 0.005
4. 0.05

2-45. If a thunderstorm has passed over a station and the last thunder was heard at 1552 LST, the time of thunderstorm ending is listed in what column and as what time on the MF1-10 form?

1. 83 as 1600
2. 83 as 1615
3. 84 as 1552
4. 84 as 1607

2-46. The 6-hourly time-check mark must be accompanied by the observer's initials on the

1. wind recorder chart
2. microbarograph chart
3. transmissometer record
4. temperature/dewpoint chart

2-47. The operation of the standard air thermometer depends upon the

1. similarity of the coefficients of expansion of glass and air
2. similarity of the coefficients of expansion of glass and alcohol or mercury
3. difference between the coefficients of expansion of air and alcohol or mercury
4. difference between the coefficients of expansion of glass and mercury or alcohol

2-48. What is the range of the standard air thermometer used by the Naval Weather Service?

1. 0° F to +140° F
2. +20° F to +120° F
3. -10° F to +110° F
4. -20° F to +120° F

2-49. The metal back of the standard air thermometer should be removed and cleaned at what intervals and with what cleaning agent?

1. At least every three months with ammonia
2. 10 to 15 minutes prior to each reading with a soft cloth dipped in light oil
3. As necessary with a solution of bicarbonate of soda
4. As required by the preventive maintenance schedule with steel wool

2-50. If the mercury column of a standard air thermometer should become separated, the final method to use to reunite it should be by

1. applying heat to the bulb by placing it near a light bulb
2. tapping the bulb
3. slinging the thermometer
4. heating the bulb over an open flame

2-51. In making a humidity check with a sling psychrometer, the operator must be careful to avoid all but which of the following?

1. Direct sun rays
2. Any trace of wind
3. Touching the bulb or stem
4. Bringing the psychrometer to a sudden stop

2-52. A rotor psychrometer differs from a sling psychrometer in that the rotor psychrometer
1. consists of two separate thermometers
2. is operated within the instrument shelter
3. contains a wick which must be moistened with distilled water before use
4. is used to obtain information from which relative humidity is determined

2-53. The two thermometers of the ML-450A/UM have a temperature range of
1. -10° F to +100° F
2. + 0° F to +110° F
3. +10° F to +120° F
4. +10° F to +110° F

2-54. When all plastic parts of the ML-450A/UM are cleaned, they should be washed with a solution of
1. ammonia and warm water
2. mild soap and warm water
3. cleaning solvent and warm water
4. gasoline and solvent

2-55. What type of batteries are used in the ML-450A/UM?
1. Size D, dry cell
2. Size C, dry cell
3. Size A, dry cell
4. Size A, water activated

2-56. How are the three batteries inserted in the ML-450A/UM?
1. Alternate with center contact first
2. Center contact last
3. Alternate with center contact last
4. Center contact first

2-57. Maintenance of the ML-450A/UM by Aerographer's Mates does NOT include which of the following?
1. Replacing the wick
2. Lubricating the instrument
3. Cleaning electrical contacts with fine sandpaper
4. Reuniting a separated column of mercury in the dry-bulb thermometer

2-58. Which of the following types of equipment is NOT issued with the Semiautomatic Meteorological Station AN/GMQ-14( )?
1. Dewpoint recording equipment
2. Dewpoint sensing equipment
3. Pressure recording equipment
4. Temperature sensing equipment

2-59. A fuzzy line on the AN/GMQ-14( ) chart may indicate the need for
1. speeding up the chart movement
2. cleaning the pen tube
3. cleaning the pen tip
4. replacing the pen

2-60. The AN/SMQ-29( ) consists of how many major components?
1. One
2. Two
3. Three
4. Four

2-61. Normal installation of the temperature and dewpoint sensor is within how many feet of the transmitter?
1. 10 ft
2. 15 ft
3. 20 ft
4. 25 ft

2-62. In which of the following ways does the recorder of the AN/GMQ-14( ) indicate the quantity of rainfall?
1. It indicates in separate steps each inch of rain that falls
2. It gives a continuous indication of the amount of rain that falls
3. It indicates in separate steps each 1/100 inch of rain that falls
4. It indicates the interval of time required for the measuring tube to fill

2-63. The bathythermograph (BT) is used to obtain information on the
1. temperature and pressure variances in the lower levels of the ocean
2. vertical temperature distribution in the upper levels of the ocean
3. surface temperature only
4. pressure variances in the upper levels of the ocean

2-64. What are two of the greatest difficulties to overcome in preparing an accurate oceanographic forecast?
1. Too many reports and inaccuracies
2. Too few reports and inaccuracies
3. Time delay and inexperience
4. Equipment error and time delay

2-65. The airborne and shipboard bathythermographs will return temperature profiles to what depths respectively?
1. 600 ft and 1,200 ft
2. 800 ft and 1,400 ft
3. 1,000 ft and 1,500 ft
4. 1,200 ft and 1,500 ft

Assignment 3

Cloud, Visibility, Radar, and Satellite Equipment

Text: Pages 70 - 122

Learning Objective: Relative to cloud and visibility observations, recognize reportable values and methods of determining clouds and visibility, and entering these observations on the MF1-10 form.

3-1. Which of the following publications should be used as the basic reference for cloud classification and identification?
1. International Cloud Atlas, NA 50-1D-509
2. Smithsonian Meteorological Tables, NA 50-1B-521
3. NAVWEASERVCOM INST 13952.1 ( )
4. Federal Meteorological Handbook No. 1

3-2. Meteorologically speaking, obscuration of the sky would be caused by
1. surface-based smoke
2. a single layer of clouds hiding the entire sky
3. several layers of clouds hiding the entire sky
4. an aurora

3-3. If a cloud layer at 3,000 feet covers 6/10 of the sky, and 3/10 of this sky cover is transparent, what is this sky cover termed?
1. Thin
2. Opaque
3. Transparent
4. Partial obscuration

3-4. Which of the following would be termed a ceiling?
1. A completely opaque "broken" cloud layer
2. A surface-based smoke obscuration of 9/10 of the sky
3. An "overcast" cloud layer with 6/10 classified as transparent
4. A layer of 5/10 cloud cover with bases at 1,500 feet

3-5. The ceiling measurement that is used when the sky is totally obscured by smoke and haze is the vertical distance from the ground to the
1. top of the obscuration
2. bottom of the obscuration
3. highest point that can be seen vertically into the obscuration
4. base of the layer of clouds immediately above the obscuration

3-6. An altocumulus cloud layer, even though attached to a cumulonimbus cloud layer, may be classified as a separate layer if the layer base levels are
1. different
2. the same
3. surface based
4. thin

3-7. Refer to table 5-1 of your text. In estimating the amount of an advancing cloud layer, it is determined that the angular elevation of the forward edge is 63° and that of the rear edge is 27°. What is the total sky cover?
1. 0.1
2. 0.2
3. 0.3
4. 0.4

3-8. Refer to table 5-2 of your text. Which of the following sky cover contractions is used when surface-based obscuring phenomena do NOT completely restrict vertical visibility?
1. X
2. -X
3. SCT
4. -SCT

3-9. If the observed ceiling value is 4,000 feet, it must be reported as
1. 4,000 scattered, AGL
2. 4,000 broken, AGL
3. 4,000 broken, MSL
4. 4,000 overcast, MSL

3-10. Refer to table 5-3 of your text. If it has been determined that the height of a cloud layer is 8,300 feet, how is this entered on MF1-10 form?
1. 83
2. 85
3. 800
4. 830

3-11. Refer to table 5-5 in your text. If a marker 17 miles from a station is visible, the reported visibility should be
1. 10 mi
2. 15 mi
3. 17 mi
4. 20 mi

3-12. The greatest visibility attained or surpassed throughout at least half of the horizon circle, NOT necessarily continuous, defines
1. prevailing visibility
2. vertical visibility
3. sector visibility
4. visibility

3-13. Refer to table 5-5 of your text. If the transmissometer indicates runway visibilities of 3/4, 1, 1 1/2, and 1 3/4 miles during a 10-minute interval, the reported runway visibility is considered
1. variable
2. unacceptable for reporting
3. only usable below one mile
4. 1 3/4 miles

3-14. Tower personnel, provided they are certified, will report prevailing visibility whenever the visibility at the usual point of observation or at the tower level decreases to less than
1. 5 mi
2. 7 mi
3. 3 mi
4. 4 mi

3-15. Tower prevailing visibility, column 4a on MF1-10, will be entered whenever the visibility at the usual point of observation is less than 4 miles and the reported tower visibility is
1. equal to the value of column 4
2. twice the value in column 4
3. more than half the value of column 4
4. less than half the value in column 4

3-16. If the prevailing visibility is 1 mile, the visibility in the northeast sector is 2 miles, in the southeast sector 1 mile, in the southwest sector 1/2 mile, and in the northwest sector 1/4 mile, what should be entered in column 13 of the MF1-10 form?
1. VSBY SW 1/2 NW 1/4
2. VSBY SE 1 SW 1/2 NW 1/4
3. VSBY NE 2 SW 1/2 NW 1/4
4. VSBY NE 2 SE 1 SW 1/2 NW 1/4

3-17. Variable visibility is entered in column 13 of the MF1-10 when the visibility is variable and less than how many miles?
1. 1 mi
2. 2 mi
3. 3 mi
4. 4 mi

3-18. The AN/GMQ-13( ) autographic records are destroyed after being retained for a period of
1. 1 mo
2. 2 mo
3. 3 mo
4. 6 mo

3-19. When should the station name, time check, and date-time group (LST) be entered on ceilometer records?
1. At the time of each 6-hourly observation
2. At the beginning and end of the chart or any detached portion thereof
3. When notified of an aircraft accident in the vicinity of the station
4. When the recorder is stopped or started

3-20. Time adjustment on the Transmissometer AN/GMQ-10( ) should be applied whenever the error exceeds the minimum of
1. 1 minute
2. 2 1/2 minutes
3. 5 minutes
4. 30 minutes

Learning Objective: Recognize functions, maintenance practices, operating principles and procedures, and construction features of the various cloud height measuring equipments.

3-21. What is the primary function of the Ceiling Light Projector ML-121 when used with a clinometer?
1. Identification of cloud types
2. Determination of cloud movements
3. Classification of cloud layers
4. Nighttime determination of cloud heights

3-22. The Aerographer's Mate should perform all the following tasks in maintaining the ML-121 EXCEPT
1. focusing the lamp
2. determining beam verticality
3. replacing lamps
4. notifying his supervisor that the lamp needs adjusting

3-23. The verticality of the ML-121 beam is checked with a theodolite and a
1. voltmeter
2. clinometer
3. spirit level
4. psychrometer

3-24. After the elevation angle of the most clearly define light spot on a cloud has been determined by sighting with a clinometer, the height of the cloud is computed by
1. dividing the length of the baseline by the tangent of the angle
2. multiplying the length of the baseline by the tangent of the angle
3. multiplying the tangent of the angle by the distance from the observer to the spot
4. taking the square root of the difference between the square of the distance from the observer to the spot and the square of the baseline

3-25. A notable difference between the shipboard type (ML-591/U) and the shore type (ML-119) clinometer is that the
1. ML-591/U is usually permanently mounted and the ML-119 is portable
2. ML-119 is usually permanently mounted and the ML-591/U is portable
3. ML-119 uses a rotating beam ceiling light
4. ML-591/U uses a rotating beam ceiling light

3-26. It is essential that the ML-591/U be located where it is out of the glare of artificial lighting whenever you
1. reorient the sighting tube to the instrument
2. remove the coated nylon bag from the instrument
3. make a sight
4. level the clinometer

3-27. The zero index may be set on the ML-591/U when the
1. bubbles in the spirit levels on the clinometer and the clinometer sighting tube read zero
2. bubbles in the spirit levels show the same inclination when placed on the clinometer and the ship's deck
3. bubble in the spirit level centers when placed on a level point on the ship's deck
4. bubble in the spirit level centers when placed on a level point at the same height as the center of the clinometer sighting tube

3-28. The cloud base height recorded from sightings with the ML-591/U clinometer will reflect the average of three readings
1. plus the height of the clinometer above sea level
2. less the height of the clinometer above sea level
3. with no correction
4. less the height of the ceiling light above sea level

3-29. The highest accurate value of the cloud height which the AN/GMQ-13( ) can determine when set on the standard baseline is approximately
1. 400 ft
2. 900 ft
3. 5,000 ft
4. 10,000 ft

3-30. The principle involved in measuring cloud height with an AN/GMQ-13( ) is based on
1. time
2. triangulation
3. intensity of projection
4. intensity of reflection

3-31. Which of the following is NOT a function of the AN/GMQ-13( ) detector?
1. To feed the amplified signal received from the cloud base to the recorder indicator
2. To amplify the light reflected from the cloud base
3. To receive the light reflected from the cloud base
4. To project a modulated light beam

3-32. The AN/GMQ-13( ) detector must be located at the same elevation as the projector and at what distance from the projector?
1. 200 to 500 ft
2. 400 to 900 ft
3. 600 to 1,000 ft
4. 800 to 1,200 ft

3-33. The projector of the AN/GMQ-13( ) has a duel light projecting system because if one lamp fails the other will continue to sweep a light beam skyward, and with two light beams

1. the degree of penetration is greater
2. breaks in clouds can be spotted easier
3. the speed of sweep is decreased
4. the rate of measurement is increased

3-34. The rotary movement of the projector of the AN/GMQ-13( ) rotates at a speed that permits the actual sweep of each optical system to last

1. 12 sec
2. 6 sec
3. 3 sec
4. 5 sec

3-35. The reflectors on both the detector and projector of the AN/GMQ-13( ) are cleaned with a clean cloth and alcohol by the technicians; however, water should be used by the Aerographer's Mate instead of alcohol in cleaning the

1. indicator cover
2. detector cover glass
3. detector reflectors
4. projector reflectors

3-36. What is the elapsed time value if a ceiling balloon begins to fade into a cloud layer 40 seconds after release and completely disappears 46 seconds after release?

1. 40 sec
2. 43 sec
3. 44 sec
4. 46 sec

Learning Objective: Recognize functions, maintenance practices, operating principles and procedures, and construction features of the various visibility measuring elements.

3-37. The AN/GMQ-10( ) directs a beam of light toward its receiver located 500 feet away. The amount of light reaching the receiver varies with the

1. time of day
2. angle of rotary motion
3. intensity of the light beam
4. density of the haze or fog in the path between the two instruments

3-38. Which component of the AN/GMQ-10( ) receiver generates a pulse signal?

1. The telescope
2. The telescope's objective lens
3. The photoelectric detector within the telescope
4. The iris diaphragm behind the telescope's objective lens

3-39. Which of the following operational functions of the AN/GMQ-10( ) is ordinarily NOT performed by Aerographer's Mates?

1. Balancing the pen
2. Calibrating the set
3. Installing the chart
4. Zero adjusting the pen

3-40. Which of the following will NOT result if the pen pressure in the AN/GMQ-10( ) writing system is too great?

1. The pen will write a heavy line
2. The pen will write intermittently
3. The response speed of the pen will be too slow
4. The pen will tend to drag toward the center of the chart

3-41. What material should be used to remove corrosion within the cabinet of the AN/GMQ-10( )?

1. Steel wool
2. Emery cloth
3. Fine sandpaper
4. Navy-approved cleaning fluid

3-42. Which of the following AN/GMQ-10( ) components require semiannual lubrication?

1. The recorder and the indicator
2. The projector and the indicator
3. The receiver and the projector
4. The projector power supply and the recorder

3-43. The OA-7900/GMQ-10 uses data from the AN/GMQ-10( ) to determine the Runway Visual Range (RVR) which represents the horizontal distance a pilot can see down the runway from the

1. approach end
2. mid point
3. landing end
4. intersection of both runways

In items 3-44 through 3-46, select from column B the component of the RVR system that performs each function listed in column A.

	A. Functions		B. Components
3-44.	Supplies light transmittance signals in the form of pulse rates	1.	AN/GMQ-10( )
		2.	ID-1939/GMQ-10
3-45.	Receives the pulse rates and correlates them with empirically obtained visibility data encoded therein	3.	CV-3125/GMQ-10
		4.	AN/GMQ-13
3-46.	Displays visually the visibility values once every minute		

3-47. The RVR system will convert the pulse rates from transmissometer sets to their corresponding visibility values. These pulse rates are based on what length baseline between the transmissometer projector and receiver without adjustment to the encoder disc?
1. 300 ft
2. 500 ft
3. 700 ft
4. 900 ft

3-48. What digital visibility display is indicated on the ID-1939/GMQ-10 if the visibility is 5,280 feet?
1. 1
2. 52
3. 528
4. 5,280

In items 3-49 through 3-51, select from column B the CV-3125/GMQ-10 control that is used to perform each function listed in column A.

	A. Functions		B. Controls
3-49.	To select the applicable visibility curves	1.	NIGHT Indicator and DAY Indicator
3-50.	To identify the visibility curve in use	2.	DAY-NIGHT selector
3-51.	To place the equipment in one of three test conditions	3.	RUNWAY LIGHT SETTING selector
		4.	MODE selector

Learning Objective: Identify the different meteorological radar sets and associated equipment, conduct operational procedures, interpret data received, and determine applicable safety precautions.

3-52. Which of the following types of equipment permit the collection of information for weather purposes in overcast conditions?
1. Range markers
2. Antennas
3. Radars
4. Cathode ray tubes

3-53. The radar electromagnetic pulse travels at the speed of
1. sound
2. light
3. 250 mph
4. 100 mph

3-54. What does the PPI scope display?

1. Altitude
2. Range only
3. Bearing only
4. Range and bearing

3-55. The radar operator must know the minimum and maximum ranges that weather echoes can be picked up by the gear and the
1. accuracy of the range and bearing display
2. frequency with which the pulse is transmitted
3. energy level of the radar
4. loss of radar energy

3-56. A factor in determining the maximum and minimum range the radar target can be detected and the power of resolution is the
1. reflected energy
2. pulse length
3. energy level of the radar
4. degree of distinguishing detail

3-57. Radar Set AN/FPS-81 is capable of detecting a concentration of high moisture content within a maximum radius of how many nautical miles?
1. 100 nm
2. 200 nm
3. 300 nm
4. 400 nm

3-58. The reason the transmitting portion of the antenna group of the AN/FPS-81 is in the shape of a parabola is to
1. concentrate the radio frequency energy into a narrow beam
2. permit the target-reflected energy to be received
3. make automatic control of the antenna possible
4. permit the RTM to be separated from the antenna by a maximum distance of 100 ft

3-59. The indicator console houses the RHI, the PPI, and the
1. RF
2. RTM
3. power source
4. Range Indicator

3-60. What is the elevation capability of the AN/FPS-106(V)?
1. -2° to +60°
2. -3° to +70°
3. -1° to +40°
4. -4° to +50°

3-61. Which component part of the AN/FPS-106(V) processes the return signal?
1. Antenna assembly
2. Control-Indicator
3. Receiver-Transmitter
4. Radome

3-62. What should the AG do, if anything, when the antenna of the AN/FPS-106 elevates only to a maximum of 50°?
1. Adjust the maximum elevation control
2. Check the down elevation reading
3. Notify maintenance personnel
4. Nothing

3-63. What does the AN/GMH-6( ) do?
1. It records weather information
2. It checks the output of a PPI scope
3. It changes the range marks in the AN/FPS-106 scope
4. It provides a copy printout of weather pictures

3-64. Servicing and maintenance of radar equipment in the meteorology spaces is the responsibility of the
1. electronics personnel
2. AG3
3. AG2
4. AG1

3-65. Working with meteorological radar may be dangerous because of the presence of
1. X-rays
2. high voltage
3. a transmitter
4. modulators

Learning Objective: Identify the different meteorological satellites and the associated ground equipment, conduct operational procedures, and interpret data received.

3-66. Instead of having several separate satellites to gather meteorological information, which of the following systems gathers the information in one satellite?
1. ITOS
2. ESSA
3. TOS
4. Nimbus

3-67. The geostationary satellite (SMS/GOES) that orbits over the equator and keeps the same region always in view has an advantage over the polar orbiting satellite because
1. most of the earth's weather develops over the equator
2. it views more of the earth's surface on each pass
3. it can watch the entire life cycle of meteorological phenomena
4. communications to the tracking station are less garbled

3-68. All aspects of data utilization, processing, and the spacecraft are classified SECRET for which of the following satellite systems?
1. ITOS/NOAA
2. SMS/GOES
3. VHRR
4. DMSP

3-69. The AN/SMQ6(V) ground station equipment consists basically of an antenna system, a receiver, a taperecorder, and a
1. power control
2. facsimile recorder
3. power source
4. circuit breaker

3-70. Which of the following is NOT one of the three modes of operation of the receiver recorder set of the AN/SMQ-6(V)?
1. MAP
2. ART
3. DRIR
4. FPRT

3-71. With the AN/SMQ-6 receiver recorder set in either the APT or the DRIR mode of operation, what type of orbital information must be furnished in order to track the satellite?
1. Zenith time
2. Predicted
3. Bearing angle
4. Line of sight

3-72. The AN/SMQ-10 shipboard readout equipment takes a maximum of how many minutes to develop satellite pictures after receiving data from one of the DMSP satellites?
1. 5 min
2. 7 min
3. 9 min
4. 10 min

3-73. The purpose of the facsimile recorder RO-402/UMH is to reproduce the meteorological information received from
1. land-line circuits
2. data processes
3. a recorder
4. satellite weather stations

Learning Objective: Recognize mechanical satellite tracking equipment and identify their purpose and uses.

3-74. To keep the antenna pointed at the satellite requires a procedure called
1. orbiting
2. following
3. tracking
4. observing

3-75. What type of satellite orbit does NOT require the use of conversion tables to determine arc distances?
1. Elliptical
2. Circular
3. Polar
4. Equatoral

Assignment 4

Communications, Office, and Specialized Meteorological Equipment

Text: Pages 123 - 163

Learning Objective: Identify various communications media used for the transmission of weather data as to their nomenclature, operating principles, capabilities, and maintenance procedures.

4-1. What two means are used for the transmission of weather data?
1. Radioteletype and radiotelegraphy
2. Landline and radio
3. Facsimile and radio
4. Teletype and radio

4-2. What two types of teletypewriters are normally employed by weather units ashore?
1. Model 28 R/O and Model 40 Teletypewriter
2. Model 28 R/O and Model 28 TT-48( )/UG
3. Model 40 Teletypewriter and Model 28 TT-48( )/UG
4. Model 28 TT-48( )/UG and Model 28 TT-69( )/UG

4-3. What model teletypewriter is used to transmit and receive weather data on the COMEDS circuits?
1. Model 28 R/O
2. Model 40 Teletypewriter
3. Model 28 TT-48( )/UG
4. Model 28 TT-69( )/UG

4-4. In regards to teletype maintenance, which of the following is NOT a function of the Aerographer's Mate?
1. Changing paper
2. Changing tape
3. Changing ribbon
4. Changing internal components

4-5. Who is responsible for teletype maintenance aboard ship?
1. Aerographer's Mate
2. Electricians
3. Radiomen
4. Ship's Servicemen

4-6. By what principle does the Alden facsimile develop transmitted data?
1. Electrosensitivity
2. Electrostatically
3. By the Diazzo method
4. Electromechanically

4-7. The Alden recorder is designed to operate at how many scans per minute?
1. 30 or 60
2. 60 or 90
3. 60 or 120
4. 90 or 120

4-8. An exact facsimile scanned in the Alden Facsimile Recorder is produced when the surface of the electrosensitive paper is plated by ions which leave the
1. helix electrode when the photoelectric cell picks up the image and converts it into electrical impulses
2. helix electrode when there is contact between the loop and helix electrode
3. loop electrode when the photoelectric cell picks up the image and converts it into electrical impulses
4. loop electrode when there is contact between the loop and helix electrode

4-9. Which control of the Alden Facsimile Recorder, when improperly set, will reduce the distinctness of the chart features?
1. White level
2. Signal level
3. Marking signal test
4. Automatic gain control

4-10. How far will the paper advance when the Automatic Fast Feed switch is in the ON position?
1. 12 in.
2. 8 in.
3. 3 in.
4. 6 in.

4-11. How does the operator of an AN/UXH-2 Facsimile Recorder know when he should change the roll of recording paper?
1. Markings on the recorder roll indicate that it should be changed
2. A "no paper" indicator light comes on as the roll nears its end
3. An audible signal is given by the limit switch to indicate when only two inches of paper remain
4. The master ac power switch is automatically shut off when only two inches of paper remain

4-12. What is the required signal strength for proper operation of the AN/UXH-2( ) facsimile recorder?
1. 1000 to 1500 Hz
2. 1200 to 2300 Hz
3. 1500 to 2500 Hz
4. 1800 to 3000 Hz

4-13. What is the operating frequency range of the R-390A/URR radio receiver?
1. 500 kHz to 32 MHz
2. 500 kHz to 60 MHz
3. 600 kHz to 60 MHz
4. 2 MHz to 30 MHz

4-14. COMEDS is an acronym for which of the following?
1. CONUS Meteorological Display Service
2. CONUS Meteorological Defense System
3. CONUS Meteorological Data System
4. CONUS Meteorological Environmental Defense Service

4-15. Where is the control center of the COMEDS circuit located?
1. ADWS Carswell AFB, Texas
2. FLENUMWEACEN Monterey, CA
3. National Weather Service Kansas City, MO
4. FLEWEAFAC Suitland, MD

4-16. What governmental authority has direct responsibility for managing landline teletypewriter network Services A, C, and O?
1. Federal Aviation Administration (FAA)
2. National Weather Service
3. Civil Aeronautics Board (CAB)
4. Federal Communications Commission (FCC)

4-17. Modernization of the FAA Communications System includes
1. combining services A, C, and O into one center
2. manual circuit control
3. delayed computerized message switching
4. separation of the circuit control

Learning Objective: Relative to the Weathervision System AN/GMQ-19( ) and AN/GMQ-27(V), recognize their operating characteristics, components and their locations, and the responsibilities of the AG3 and AG2 relative to their operation and maintenance.

4-18. All AN/GMQ-19( ) and AN/GMQ-27(V) stations have the capability of transmitting weather information by
1. radar
2. television
3. telephone
4. teletype

4-19. The light table of the AN/GMQ-27( ) functions for the illumination of
1. opaque weather maps for local pilot briefings
2. transparent weather maps being transmitted over the system
3. opaque weather maps for transmission by closed-circuit television
4. receipt of data from pilot to forecaster

4-20. What should be used to clean the glass on the television viewer of the weather vision?
1. Soap and water
2. Aliphatic naphtha
3. A solution of water and ammonia
4. Alcohol

4-21. What feature of the COMEDS reduces the number of errors to near zero?
1. The preparation of messages on the keyboard display
2. The printer unit
3. Tape preparation
4. American Standard Code for Information Exchange

4-22. Who is responsible for supplying NOTAMS to base operations?
1. Flight terminal personnel
2. Weather office personnel
3. Air operation personnel
4. Communications personnel

4-23. Responsibility for assigning precedence to a naval message lies with the
1. originator
2. communications watch officer
3. duty officer
4. commanding officer or officer-in-charge as appropriate

4-24. Refer to table 7-1 in your textbook. Normally, a hurricane warning message will have what precedence assigned to it?
1. Flash
2. Immediate
3. Priority
4. Routine

4-25. Who is responsible for assigning the date-time group (DTG) to messages?
1. Originator
2. Duty officer
3. Message center personnel
4. Weather office personnel

Refer to table 7-2 in your textbook. In items 4-26 through 4-28, select from column B the GMT equivalent of each local time in column A.

	A. Local Times		B. Equivalent GMT Times
4-26.	1600S	1.	0400Z
4-27.	1800F	2.	1000Z
4-28.	0700P	3.	1200Z
		4.	2200Z

4-29. Which of the following terms is most indicative of the reason why Standard Subject Identification Codes are now used with naval communications messages?
1. Speed
2. Brevity
3. Accuracy
4. Time

Learning Objective: Identify office equipments as to their nomenclature, principles of operation, operating and maintenance procedures.

4-30. What type of duplicating process is employed by the ditto machine?
1. Electromagnetic
2. Spirit
3. Light sensitive
4. Dry electrical

4-31. What is the advantage of using the purple ditto master as the base color?
1. It produces a larger quantity of legible copies
2. It produces contrast
3. It is easier to correct an error
4. It is the only color available as the base color

In items 4-32 through 4-34 select from column B the function performed by components of the ditto machine listed in column A.

	A. Component		B. Function
4-32.	Roller B	1.	Ejects copy into the receiving tray
4-33.	Roller C	2.	Moistens the paper
4-34.	Roller D	3.	Pushes the paper to roller B and C
		4.	Absorbs excess fluid

4-35. What process is used by the Xerox machine in reproducing copies?
1. Spirit
2. Chemical
3. Dry electrical
4. Light sensitive

In items 4-36 through 4-38 select from column B the definition of the terms listed in column A.

	A. Term		B. Definition
4-36.	Toner	1.	The lightness or darkness of the copy
4-37.	Misfeed		
4-38.	Print density	2.	Fine black powder that forms copy image
		3.	The copy paper used
		4.	A paper jam

4-39. What developing process is used by the Ozalid machine?
1. Dry electrical
2. Spirit
3. Chemical
4. Fuser

4-40. What is the normal operating temperature of the Ozalid machine?
1. 100° to 180° F
2. 150° to 200° F
3. 180° to 210° F
4. 200° to 230° F

4-41. How often should the ammonia supply in the Ozalid machine be replenished?
1. Daily
2. Weekly
3. Bimonthly
4. Monthly

4-42. When should the bearing and drive assembly of the Ozalid machine be lubricated?
1. Daily, before each use
2. Weekly
3. Monthly
4. Semiannually

4-43. Which part of the code-a-phone acts as the microphone?
1. Ear piece
2. Mouth piece
3. Pitch amplifier
4. Volume control amplifier

4-44. How often should the platen on the typewriter be cleaned?
1. Daily
2. Biweekly
3. Weekly
4. Bimonthly

Learning Objective: Identify the operating principles, components, and equipment associated with the radiosonde transmitter.

4-45. What instrument is used to obtain a vertical profile of the atmosphere?
1. A transducer
2. A radiosonde transmitter
3. A transceiver
4. A humidity chamber

4-46. Which of the following is NOT transmitted by the radiosonde transmitter?
1. Dew-point
2. Pressure
3. Temperature
4. Relative humidity

4-47. What is the purpose of the signal generator?
1. To calibrate the radiosonde recorder
2. To calibrate the radiosonde transmitter prior to release
3. To ensure proper operation of the radiosonde
4. To ensure a stable atmosphere for the radiosonde transmitter

4-48. What piece of equipment is used to provide a stable atmosphere for the 403 MHz radiosonde transmitter?
1. AN/GMM-1
2. AN/UMM-1
3. AN/GMM-3
4. ML-428/UM

4-49. Which of the following performs as a frequency meter and power output meter for the AN/AMT-4?
1. Battery test set
2. AN/UMM-1
3. AN/GMD-1
4. Test Set TS-538/U

Learning Objective: Identify the various balloons as to their nomenclature, uses, and associated components and the instrumentation used in making upper air soundings.

4-50. What two standard size balloons are used for PIBALs?
1. 30 and 100 gram
2. 50 and 100 gram
3. 100 and 300 gram
4. 300 and 600 gram

4-51. What is the reason for having different sizes and colors for PIBAL balloons?
1. Ease in accountability
2. Various weather conditions
3. Various types of stations
4. Ease in identifying size by color

4-52. What size balloon, if any, is standard for radiosonde observations?
1. No standard size
2. 300 gram
3. 600 gram
4. 1,200 gram

4-53. What is the primary factor to consider in determining if a neoprene balloon is to be conditioned?
1. Desired height to be obtained
2. Storage conditions
3. Desired ascension rate
4. Local weather conditions

4-54. What is the purpose of the balloon shroud?
1. To facilitate handling and inflation of the balloon during a period of high winds
2. To tie the balloon down during inflation
3. To decrease the decension rate after the balloon bursts
4. To condition the balloon prior to release

4-55. The braking mechanism of the train regulator permits the train assembly to unwind at a nominal rate of how many feet per minute?
1. 6 fpm
2. 9 fpm
3. 12 fpm
4. 15 fpm

4-56. When used, where should the train regulator be attached?
1. Between the parachute and balloon
2. Between the balloon and radiosonde
3. Between the balloon and parachute
4. Between the parachute and radiosonde

4-57. How does the theodolite telescope differ from the transit telescope?
1. The line of sight is bent through an angle of 30°
2. The line of sight is bent through an angle of 45°
3. The line of sight is bent through an angle of 60°
4. The line of sight is bent through an angle of 90°

4-58. When a balloon is tracked with a theodolite, what causes the image to appear inverted?
1. The absence of nonerecting eyepieces
2. The addition of nonerecting eyepieces
3. The addition of two lenses
4. The glass prism in the eyepiece

4-59. What feature of the shipboard theodolite improves the visibility?
1. The glass prism
2. The gimble assembly
3. The ray filters
4. The artificial horizon

4-60. What part of the shipboard theodolite tends to keep the instrument in the vertical?
1. The tripod
2. The counterweight
3. The gimbal assembly
4. The internal spiral cam

Learning Objective: Identify the computerized network for dissemination of weather and oceanography, products, its operating principles, and the command exercising control over it.

4-61. Which system is the primary computerized network for dissemination of meteorological and oceanographic products?
1. NEDS
2. NEDN
3. COMET
4. COMEDS

4-62. Which command generates all the basic computer environmental analyses and forecasts distributed via the NEDN circuit?
1. FWC Pearl Harbor, HI
2. FWC Norfolk, VA
3. FWF Suitland, MD
4. FNWC Monterey, CA

4-63. What provides the capability for transmission of digitally plotted analyses to NEDN subscribers across the United States?
1. Tielines operated by FLENUMWEACEN Monterey
2. North and south tielines out of Chicago and Dallas
3. Tielines operated by all FLEWEACENs
4. East and west coast tielines out of Norfolk and Monterey

4-64. What is the maximum number of charts that can be displayed simultaneously on the NEDS display unit?
1. Five
2. Two
3. Seven
4. Four

Assignment 5

Watch Routines

Text: Pages 164 - 192

Learning Objective: Recognize schedules, forms, and procedures for recording surface weather data.

5-1. Under which of the following situations is a ship that is in port NOT required to continue regular observing and reporting of observations?
1. The ship is alongside a tender
2. The ship is assigned as the guard weather ship
3. The ship is at anchor in a port that is serviced by an NWSED
4. The ship has the Senior Officer Present Afloat embarked

In items 5-2 through 5-4, select from column B the WMO Region that is applicable to the area listed in column A.

A. Area	B. Regions
5-2. North America	1. III
5-3. Europe	2. IV
5-4. Southwest Pacific	3. V
	4. VI

5-5. Which of the following publications contains instructions for recording surface weather observations aboard ship?
1. Codes Manual
2. FMH No. 1
3. FMH No. 2
4. NWSC form 3140/8

5-6. Which of the following types of observations should be taken immediately following notification of an aircraft mishap?
1. Local extra
2. Record local
3. Special local
4. Local

5-7. At what time should a new NWSC form 3140/8 be started?
1. Midnight Greenwich mean time
2. 0000 LST
3. 0800 Greenwich mean time
4. 0800 LST

5-8. What is/are the correct entry(ies) on an MF1-10 or NWSC form 3140/8 for missing data?
1. / only
2. / or M, as appropriate
3. M only
4. M or X

5-9. What entry is made in column 13 of MF1-10 when an observation has been taken late and NO appreciable changes have occurred since the scheduled time?
1. DLAD
2. NIL
3. LATE
4. NO SIG

5-10. How are errors corrected on the MF1-10 after the report has been disseminated?
1. Draw a red line through the erroneous data and enter the correction in pencil above it on all copies
2. Erase the erroneous data from all copies and record corrected data in red
3. Draw a line through the erroneous data and enter corrections in pencil on the next line
4. Draw a red line through the erroneous data and enter the correction in red above it on all copies

5-11. During periods of radio silence, which publication contains instructions concerning the transmission of weather observations?
1. FMH #1
2. FMH #5
3. NWP-16
4. NAVAIR 50-1P-11

5-12. In which column of the MF1-10 is supplementary data entered?
1. Column 5
2. Column 9
3. Column 11
4. Column 13

5-13. When conditions are stable, which of the following elements of a surface observation should be evaluated last?
1. Pressure
2. Wind
3. Temperature
4. Sky condition

Learning Objective: Relative to precipitation, recognize types, symbols, terminology, and intensity.

5-14. Refer to table 10-1 in your text. All the following hydrometeors are reported as obstructions to vision except the one represented by which of the following symbols?
1. RW
2. IF
3. BS
4. GF

5-15. Refer to table 10-1 in your text. What kinds of atmospheric phenomena are represented by the symbols ZR, IP, and SG which appear on weather reports and charts?
1. Lithometeors which are considered weather elements
2. Hydrometeors which are considered weather elements
3. Lithometeors which are considered obstructions to vision
4. Hydrometeors which are considered obstructions to vision

5-16. Which of the following symbols, if any, is used to indicate moderate intensity of a weather element?
1. +
2. -
3. ±
4. None is used

5-17. Refer to table 10-4 in your text. If snowfall reduces the visibility at a station to 1/2 mile, the intensity of snow is termed
1. slight
2. light
3. moderate
4. heavy

Learning Objective: Recognize the precedence for making entries on MF1-10.

5-18. Which of the following should be entered last in the Weather and Obstructions to Vision column of MF1-10?
1. Thunderstorm
2. Fog
3. Rain
4. Freezing drizzle

5-19. Which of the following remarks on MF1-10 has the highest precedence?
1. Tower visibility
2. Freezing level data
3. Runway conditions
4. Runway visibility

Learning Objective: Recognize terminology, definitions, and methods of observing sea waves.

5-20. The time between consecutive wave crests is called the wave
1. interval
2. period
3. span
4. duration

5-21. For observational purposes, sea waves are defined as those waves which are
1. moving into the area
2. locally generated
3. of sufficient height to be measured
4. caused by storm action

5-22. The average vertical distance in feet from the wave crest and the adjacent trough defines the wave
1. height
2. train
3. length
4. period

5-23. When wave height observations are made, the best estimate can be obtained by

1. positioning yourself on the superstructure at a point in line with wave crests, then computing the distance from your position to the ship's waterline
2. using the relative heights of two known points on the side of your ship
3. observing the height of waves against the side of another ship in company
4. using a floating mark

Learning Objective: Recognize the purpose and content of common meteorological codes.

5-24. Which of the following codes is used outside the U.S. for the same purpose as the Airways code is used within the U.S.?

1. SPESH
2. METAR
3. SHRED
4. AERO

5-25. Which of the following FM codes is used to transmit synoptic reports from U.S. ships?

1. FM 21. ( )
2. FM 22. ( )
3. FM 26. ( )
4. FM 36. ( )

5-26. Which of the following codes is based on the National Weather Service Aviation Forecast (Terminal) code?

1. PLATF
2. TAF
3. ARFOR
4. ROFOR

5-27. How is a forecasted ceiling of 18,000 feet entered in the PLATF code?

1. 100+
2. 150
3. 180
4. 200

5-28. What is indicated by the use of the letter "C" in a PLATF report?

1. Wind speed is forecast to be less than 5 knots only
2. Clear sky condition
3. Wind speed is forecast to be less than 2 knots only
4. Ceiling height follows

5-29. Which of the following terms is used to modify a PLATF when changes are expected to occur more than once or twice during the forecast period?

1. OCNL
2. TEMP
3. INTER
4. GRADU

5-30. Which of the following codes is a route forecast?

1. ARFOR
2. TAF
3. FORRO
4. ROFOR

Learning Objective: Recognize the definition of terms as used in satellite meteorology.

In items 5-31 through 5-33, select from column B the term that is applicable to each definition listed in column A.

	A. Definitions	B. Terms
5-31.	The point at the Equator where the satellite crosses from the Southern to the Northern Hemisphere	1. Perigee 2. Apogee 3. Ascending mode
5-32.	The amount of turning, measured in degrees longitude, that takes place during one nodal period	4. Nodal increment
5-33.	The point in orbit where the satellite is farthest from the earth's center	

Learning Objective: Recognize the various satellite systems that are utilized in the sensing and transmitting of meteorological data.

5-34. What is the most commonly used satellite real-time data system?

1. VISSR
2. VHR
3. SR
4. VTPR

5-35. Which of the following satellite systems measures radiation in the visual and infrared regions of the spectrum?
1. VIR
2. SR
3. IRV
4. VTPR

5-36. Which of the following satellites does NOT transmit meteorological information by direct readout to ground stations?
1. TIROS
2. ITOS
3. NOAA
4. DMSP

5-37. Which of the following satellites has a geostationary orbit?
1. ITOS
2. TIROS
3. DMSP
4. SMS

5-38. Which of the following satellite systems employs two polar orbiting satellites?
1. ITOS
2. DMSP
3. GOES
4. SMS

5-39. Of the following satellite systems, which has the primary objective of providing maximum responsiveness to the military decision maker?
1. ITOS
2. GOES
3. SMS
4. DMSP

Learning Objective: Relative to meteorological satellites, identify essential orbital data, their principle of operation, and correctly interpret the received data.

5-40. Which of the following information is necessary in order to utilize the data transmitted by a satellite?
1. The APT predict message
2. The type of sensor used by the satellite
3. The altitude of the satellite
4. The type of orbit of the satellite

5-41. Which publication contains detailed information on weather radar observations?
1. FMH #3
2. FMH #5
3. FMH #7
4. FMH #8

5-42. Which part(s) of an APT predict message provide(s) data for plotting the subpoint track of satellite?
1. I only
2. II only
3. II and III
4. I and III

5-43. The task of keeping the receiver tuned and the antenna pointed at the satellite is referred to as
1. interrogating
2. integrating
3. gridding
4. tracking

5-44. What feature(s) of the scanning radiometer allow(s) for complete coverage over the dark areas as well as the daylight areas of the earth?
1. The radiometer senses radiant energy only
2. The radiometer senses reflected energy only
3. The radiometer senses spectral energy
4. The radiometer senses both reflected and radiant energy

5-45. What is represented by the various shades of gray which appear in SR pictures?
1. Effective visible light
2. Effective radiating temperatures
3. Variations in reflectivity of visible light
4. Variations in emission of visible light

5-46. How many shades of gray can be readily distinguished in SR infrared facsimile pictures?
1. Five
2. Two
3. Three
4. Four

5-47. What is represented by white areas in SR infrared pictures?
1. Desert areas
2. Fog
3. Background noise
4. High clouds

Learning Objective: Identify oceanographic parameters.

5-48. Waves generated by local winds are referred to as
1. sea waves
2. local sea
3. swell waves
4. combined seas

5-49. "The time interval between consecutive troughs of a wave," defines wave
1. height
2. speed
3. period
4. length

5-50. Which term is used to describe the average height of the highest one-third of the waves?
1. Mean wave height
2. Significant wave height
3. Median wave height
4. Average wave height

Learning Objective: Recognize standard procedures for observing and recording sea conditions.

5-51. The best position on a ship from which wave period observations may be made is
1. the windward side of the stern
2. amidships near the centerline
3. the deck above the bridge
4. the windward side of the bow

5-52. Which of the following statements is correct with respect to wave height observations?
1. Low waves tend to be underestimated; high waves tend to be overestimated
2. Both low waves and high waves tend to be underestimated
3. Both low waves and high waves tend to be overestimated
4. Low waves tend to be overestimated; high waves tend to be underestimated

5-53. Which of the following wave height categories is to be recorded when wave height observations are made?
1. Average of the highest waves
2. One-half the average of the highest waves
3. Average of all wave heights
4. Significant wave height

5-54. Waves which are uniformly shaped, low, and have rounded tops and regular heights are classified as
1. storm action waves
2. swell waves
3. following waves
4. sea waves

Learning Objective: Identify various types of winds aloft observations.

In items 5-55 through 5-58, select from column B the definition of each type of winds aloft observation listed in column A.

	A. Types	B. Definitions
5-55.	PIBAL	1. A measurement by electronic means of wind direction and speed from calculations which combine the angular elevation and azimuth of a radiosonde signal with the computed height of the radiosonde
5-56.	RABAL	2. A simultaneous measurement by electronic means of pressure, temperature, wind direction, and speed of the air above the earth's surface
5-57.	RAWIN	3. A measurement of wind direction and speed by visually observing with a theodolite the successive positions of a free balloon which is assumed to have a fixed ascensional rate
5-58.	Rawinsonde	4. A measurement of wind direction and speed by visually observing a radiosonde's ascent with a theodolite

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Learning Objective: Recognize the schedule, code, basic content, and forms used for upper air/wind observations.

5-59. At what times are upper wind observations desired from fleet units?
1. 0000 and 1200 GMT
2. 0600 and 1800 GMT
3. 0600 and 1800 LST
4. 0000 and 1200 LST

5-60. Which form is used to plot computed wind direction and speed to corresponding altitudes for coding purposes?
1. MF5-20N
2. OPNAV 3140-27
3. MF1-12
4. OPNAV 3140-14

5-61. What charts are used to plot, compute, and encode radiosonde data?
1. Winds aloft plotting charts
2. RECCO charts
3. Adiabatic charts
4. MF5-20Ns

5-62. Which of the following codes is used by land stations for reporting wind conditions in the upper air?
1. FM 32.( )
2. FM 33.( )
3. FM 34.( )
4. FM 36.( )

5-63. Which of the following is NOT a standard isobaric surface?
1. 850 mb
2. 700 mb
3. 600 mb
4. 250 mb

Learning Objective: Recognize type and content of miscellaneous codes.

5-64. Which of the following Text Element Identifiers of a PIREP is used for wind information?
1. WI
2. FLW
3. FLWV
4. WV

5-65. What is the code name for a report from a meteorological reconnaissance flight?
1. RECCO
2. MERF
3. PIREP
4. RECON

Assignment 6

Watch Routines (Continued)

Text: Pages 193 - 248

Learning Objective: Recognize the procedures used to plot weather information ashore and afloat and the position of weather elements around the station circle.

6-1. When you plot a surface synoptic chart, which of the following is the most important?
   1. Neatness
   2. Accuracy
   3. Speed
   4. Discarding erroneous reports

6-2. The maps and charts plotted at any given weather station are determined by all but which of the following?
   1. Geographical location
   2. Area of responsibility
   3. Operational requirements
   4. Present weather conditions

In items 6-3 through 6-5, refer to figure 11-1 of your textbook. Select from column B the station circle position in which each weather element listed in column A will be plotted on a land synoptic map.

A. Weather Elements	B. Station Circle Positions
6-3. ww Present weather	1. East of station circle
6-4. app barometric tendency	2. South of station centerline
6-5. C_L Low clouds	3. West of station circle
	4. North of station centerline

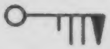
6-6. Which of the following is the source for encoding instructions for synoptic observations made at land stations and ship stations?
   1. Chapter 21, AG 3 & 2, NAVEDTRA 10363-E
   2. FMH No. 2, Synoptic Code (NA-50-ID-2)
   3. Manual for Synoptic Code (NA-50-ID-506)
   4. FMH No. 6, Upper Wind Codes

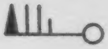
In items 6-7 through 6-9, refer to figure 11-3 in your textbook. Select from column B the station circle position in which each weather element listed in column A will be plotted in shipboard code plotting.

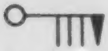
A. Weather Elements	B. Station Circle Positions
6-7. T_dT_d Dewpoint temperature	1. Southeast quadrant
6-8. TT Temperature	2. Southwest quadrant
6-9. PPP Sea level pressure	3. Northeast quadrant
	4. Northwest quadrant

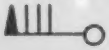
6-10. In which order are the symbols for low, middle, and high clouds arranged around the station circle of the station model for plotting airways reports?
   1. CL - south of centerline; CM - north of centerline; CH - north of centerline above CM
   2. CL - north of centerline; CM - north of centerline above CL; CH - south of centerline
   3. CL - north of centerline; CM - north of centerline above CL; CH - north of centerline above CM
   4. CL - south of centerline; CM - south of centerline below CL; CH - north of centerline

6-11. Assume that the surface wind at a weather station is from 090° at 75 knots. How should this be plotted?

1. 

2. 

3. 

4. 

Learning Objective: Recognize procedures and symbols used for drawing and labeling isobars, fronts, air masses, and weather when making a surface analyses.

6-12. What must you do prior to drawing the past fronts and pressure systems on the current surface chart?
1. Sketch the isobars lightly on the current chart
2. Check for obviously erroneous reports on the current chart
3. Sketch the fronts and pressure centers lightly on the current chart
4. Revise the previous analysis, as necessary, for reports received after the chart analysis was completed

6-13. What action should you take in connection with a doubtful plot discovered during your preliminary analysis of a weather map?
1. Check it for accuracy against the original report and retain any usuable portions
2. Remove it from the weather map and exclude it from further consideration
3. Discard it as soon as you have determined the cause of error
4. Discard it immediately

6-14. If the reported wind speeds in three areas of a weather map are: Area A, 10 knots; Area B, 20 knots; and Area C, 30 knots; the isobars will be
1. spaced the same in all three areas
2. closer together in Area A
3. closer together in Area B
4. closer together in Area C

6-15. Synoptic observations made at what hours are normally used for the plotting of surface charts?
1. 0000 and 1200GMT
2. 0000, 0800, and 1600GMT
3. 0000, 0600, 1200, and 1800GMT
4. 0000, 0400, 0800, 1200, 1600, and 2000GMT

6-16. If isobars are being drawn on a large weather map, those which are normally drawn last are the ones on that part of the map that
1. cover ocean areas
2. represent areas of strong wind
3. represent the center of a low-pressure area
4. represent the center of a high-pressure area

6-17. Which of the following analysis procedures will be used to complete the basic isobaric analysis of a surface chart?
1. Sketching the isobars and fronts lightly on the chart
2. Smoothing out all isobars drawn on the chart and sketching in lightly the positions of the fronts
3. The 2-station analysis method, projecting isobars to the proper positions between stations, and searching downwind for new points for the isobars
4. The 2-station analysis method, projecting isobars to the proper positions between stations, and searching upwind for new points for the isobars

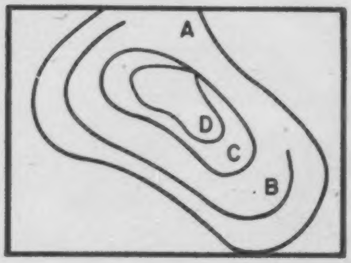
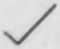


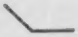
Figure 11A.—Isobars.

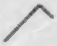
6-18. Which of the isobars is NOT drawn correctly?
1. A
2. B
3. C
4. D

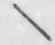
6-19. Normally, a station ahead of a cold front will show a pressure tendency that is
1. steady
2. falling
3. rising steadily
4. rising unsteadily

6-20. Which symbol is used on a weather map to show a fall and then a rise in pressure, indicating that a cold front passed the station concerned during the 3-hour period prior to map time?

1. 

2. 

3. 

4. 

6-21. A station in the United States that is ahead of a cold front will usually report the wind to be from the
1. north or northeast
2. east or southeast
3. south or southwest
4. west or northwest

6-22. Continuous precipitation generally occurs and lasts for several hours after the passage of a/an
1. occluded front
2. active warm front
3. fast-moving cold front
4. slow-moving cold front

6-23. After the passage of an active warm front, a station in the United States will generally report the wind to be from the
1. east
2. southeast
3. northwest
4. southwest

6-24. If a station is located 450 miles east of a warm front that is moving due eastward at a uniform speed of 600 miles per day, approximately how many hours will pass before precipitation associated with the front can be expected at the station?
1. 6 hr
2. 12 hr
3. 18 hr
4. 24 hr

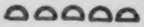
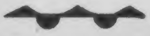
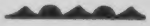
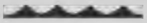
6-25. Which of the following statements about occluded fronts is correct?
1. The weather clears rapidly after the passage of a warm-type occlusion, but precipitation and icing occur after the passage of a cold-type occlusion
2. Precipitation is ordinarily produced by the cold-type but not the warm-type
3. Thunderstorms are ordinarily produced by the warm-type but not the cold-type
4. Precipitation is spread over a much wider area in the warm-type than in the cold-type

6-26. In the final analysis of a weather map, how must all low-pressure centers be labeled?
1. L in blue
2. L in red
3. LOW in blue
4. LOW in red

6-27. What is the best indication of the existence of a quasi-stationary front?
1. Wind shift
2. Pressure rise
3. Cloud deck
4. Temperature drop

6-28. Isobars should be drawn at a front so that they are
1. parallel to the front
2. perpendicular to the front
3. V-shaped and pointing toward lower pressure
4. V-shaped and pointing toward higher pressure

In items 6-29 through 6-32, select from column B the one color reproduction weather symbol associated with each surface analysis feature in column A.

	A. Analysis Features	B. Symbols
6-29.	Occluded front	1. 
6-30.	Cold front	2. 
6-31.	Quasi-stationary front	3. 
6-32.	Frontogenesis resulting in warm front aloft	4. 

In items 6-33 through 6-35, select from column B the definition of each isobaric pattern in column A.

A. Isobaric Patterns

6-33. Trough

6-34. Ridge

6-35. Col

B. Definitions

1. The region between two highs and two lows
2. The region between primary and secondary fronts
3. An elongated area of relatively low pressure
4. An elongated area of relatively high pressure that extends from the center of an anticyclone

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6-36. What are isallobars?
1. Lines of equal pressure
2. Lines of equal temperature
3. Lines of equal pressure changes
4. Lines of equal temperature changes

6-37. What symbol and color are used to denote a maritime polar air mass?
1. mP in red
2. mP in blue
3. Mp in blue
4. Mp in red

6-38. Dashed red lines on a weather chart indicate which of the following?
1. Isobars for plus values
2. Isobars for minus values
3. Isallobars for plus values
4. Isallobars for minus values

6-39. A continental polar air mass that is colder than the surface over which it is passing is denoted by
1. cPk in blue
2. Cpk in red
3. cPw in blue
4. CPw in red

In items 6-40 through 6-42, select from column B the prescribed weather map coloring that shows the intensity of each precipitation area listed in column A.

A. Precipitation Areas

6-40. Fog

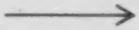
6-41. Intermittent precipitation

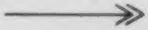
6-42. Continuous precipitation

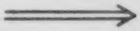
B. Colorings

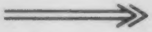
1. Light green shading
2. Light green hatching
3. Light red hatching
4. Light yellow shading

6-43. Refer to figure 11-12 in your textbook. In forecasting frontal movement, which symbol must you use to indicate the probable path of a front and its position in 12 hours?

1. 

2. 

3. 

4. 

Learning Objective: Relative to upper air pressure analysis, recognize the function and source of information for constant pressure charts, conditions associated with pressure analysis, and symbols and procedures for plotting constant pressure data.

6-44. A 700-millibar constant pressure chart shows atmospheric conditions at an approximate altitude of
1. 113 m
2. 1,463 m
3. 3,010 m
4. 5,578 m

6-45. What are the wind speed and direction as indicated in figure 11-14 in your textbook?
1. 55 knots from 090°
2. 55 knots from 270°
3. 60 knots from 097°
4. 60 knots from 277°

6-46. The plotting and analysis of constant pressure charts are based on radiosonde and rawinsonde releases made daily at which time?
1. 0000 and 1200GMT
2. 0000, 0800, and 1600GMT
3. 0000, 0600, 1200, and 1800GMT
4. 0000, 0400, 0800, 1200, 1600, and 2000GMT

6-47. In a cold core high, how does temperature change toward the center, and how does pressure change with height?
1. Temperature decreases toward the center, and pressure decreases with height
2. Temperature increases toward the center, and pressure decreases with height
3. Temperature decreases toward the center, and pressure increases with height
4. Temperature increases toward the center, and pressure increases with height

6-48. The vertical spacing of the isobars is farther apart in the center than on the outside in the case of
1. cold core lows and warm core highs
2. cold core lows and cold core highs
3. warm core lows and cold core highs
4. warm core lows and warm core highs

6-49. Which of the following statements is correct regarding the vertical axes of pressure systems?
1. Both high and low pressure systems normally slope northward
2. The centers of pressure systems aloft seldom coincide with the surface center
3. The centers of pressure systems aloft normally coincide with the surface center
4. High pressure systems normally slope toward colder air aloft and lows slope toward warmer air

6-50. Contours bear the same relationship to upper air analyses as which of the following bear to surface analyses?
1. Isobars
2. Isotherms
3. Isopleths
4. Isallobars

In items 6-51 through 6-53, select from column B the upper air chart marking applicable to each constant pressure chart element listed in column A.

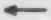
	A. Chart Element	B. Chart Markings
6-51.	Isotachs	1. Solid black pencil lines
6-52.	Isoheights	2. Solid red lines
6-53.	Isodrosotherms	3. Very light solid green lines
		4. Short dashed green lines

6-54. Ordinarily the first lines that should be drawn on a constant pressure chart represent the
1. temperature changes
2. current pressure centers
3. current frontal structures
4. past history of fronts and pressure systems

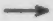
Learning Objective: Recognize basic factors and characteristics of ocean waters with respect to sea surface temperature analysis.

6-55. Which arrow represents the correct plot for sea flow toward 340°?

1.

2. 

3.

4. 

6-56. Any approach to SST analysis must consider all but which of the following factors?
1. Orientation of the water masses
2. Current structure
3. Local characteristics of the ocean area
4. Depth of the water

6-57. Cold currents ordinarily are horizontally stable but less stable vertically as they flow into warmer waters; and warm currents are
1. always horizontally stable and vertically unstable
2. normally vertically stable and less stable horizontally
3. normally stable both horizontally and vertically
4. normally unstable both horizontally and vertically

6-58. How is the wave train direction indicated on a sea condition analysis chart?
1. By solid isopleths
2. By isohalines
3. By dashed isopleths
4. By arrows

Learning Objective: Relative to radiological fallout (RADFO), recognize factors upon which the forecasts are based and the use of the RADFO diagram.

6-59. Which of the following factors necessary for the prediction of the fallout area can be available before detonation of a nuclear weapon?
1. Yield of the weapon
2. Location of the burst
3. Atmospheric wind structure
4. Time of day and season of the year

6-60. A black elliptical contour line on the RADFO diagram indicates the limits of the
1. potentially hazardous area when a low-yield explosion occurs at surface zero (SZ)
2. potentially hazardous area when a high-yield explosion occurs at SZ
3. area in which fallout occurs simultaneously when a low-yield explosion occurs at SZ
4. area in which fallout occurs simultaneously when a high-yield explosion occurs at SZ

Learning Objective: Recognize the use and functions of the SKEW-T Diagram and other various charts available within a weather office.

6-61. The level at which a parcel of air becomes saturated when lifted dry adiabatically is called the
1. LCL
2. LFC
3. CCL
4. CTL

6-62. The level at which a parcel of air, if heated sufficiently from below, will rise adiabatically until it is just saturated describes the
1. LCL
2. CCL
3. LFC
4. CTL

In items 6-63 through 6-65, select from column B the information depicted on each type of chart listed in column A.

A. Charts	B. Information
6-63. Prognostic	1. Distribution of echoes from hourly radar reports
6-64. Radar summary	2. Projections of basic charted information into the future
6-65. Weather depiction	3. Distribution of clouds from satellite pictures
	4. Outlines of areas of significant weather

Assignment 7

The Governing Fundamentals of Meteorology

Text: Pages 249 - 267

Learning Objective: Recognize the relationship beween the sun's energy and the earth's motion in the creation of day and night, heat zones, and seasons of the year.

7-1. The sun radiates electromagnetic energy in all directions. Most of that energy is in the form of
1. heat waves
2. light waves
3. electric waves
4. ultraviolet waves

7-2. The surface of the sun is referred to as the
1. chromosphere
2. corona
3. photosphere
4. solar atmosphere

7-3. Which of the following comprise the solar atmosphere?
1. Photosphere, radiative zone, and corona
2. Photosphere, chromosphere, and corona
3. Chromosphere, radiative zone, and corona
4. Chromosphere, convective zone, and corona

7-4. The greatest solar flare activity is generally associated with the maximum
1. plage activity
2. chromosphere activity
3. magnetic activity
4. sunspot activity

Items 7-5 and 7-6 refer to the following motions of the earth:
A. Rotation on its axis
B. Revolution around the sun
C. Precessional motion
D. Solar motion

7-5. Of the four motions, which two are the most important to meteorology?
1. A and B
2. A and C
3. B and C
4. C and D

7-6. Which motion is responsible for daylight and darkness for a given area?
1. A
2. B
3. C
4. D

7-7. The area to the north of the Arctic Circle is in darkness during which period of the earth's revolution?
1. The vernal equinox
2. The summer solstice
3. The winter solstice
4. The autumnal equinox

In items 7-8 through 7-11, select from column B the location on the earth which receives the most perpendicular rays of the sun on each date listed in column A.

	A. Dates	B. Locations
7-8.	March 21	1. Latitude 23 1/2° S
7-9.	June 21	2. Equator
7-10.	September 22	3. Latitude 23 1/2° N
7-11.	December 22	

In items 7-12 through 7-14, select from column B the northernmost boundary of each of the earth's light (or heat) zones listed in column A.

	A. Light (Heat) Zones	B. Northernmost Boundaries
7-12.	Torrid	1. Equator
7-13.	North Temperate	2. Tropic of Capricorn
7-14.	South Temperate	3. Tropic of Cancer
		4. Arctic Circle

Learning Objective: Relative to radiation, recognize phenomena related to incoming solar radiation (insolation), its disposition, and balance in the atmosphere.

7-15. Which means of heat transfer is most important since all of the heat of the earth is received through this means?
1. Advection
2. Conduction
3. Convection
4. Radiation

7-16. Approximately one half of the electromagnetic energy emitted by the sun is in the form of
1. heat
2. visible light
3. gamma rays
4. infrared rays

7-17. Which of the following statements concerning radiation and reradiation is correct?
1. The earth receives long wave radiation from the sun and reradiates it into space in long waves
2. The earth receives long wave radiation from the sun and reradiates it into space in short waves
3. The earth receives short wave radiation from the sun and reradiates it into space in long waves
4. The earth receives short wave radiation from the sun and reradiates it into space in short waves

7-18. The rate at which solar radiation is received by a unit (horizontal surface) at any point on the earth's surface is known as
1. temperature
2. solar constant
3. molecular stimulation
4. insolation

7-19. Of the wavelengths that strike the earth's surface, albedo is the percentage of those which are
1. reflected
2. dispersed
3. absorbed
4. scattered

7-20. Which of the following surfaces have the lowest albedo when the sun is directly overhead?
1. Water surfaces
2. Dark forests
3. Old, dirty snow surfaces
4. Upper surfaces of clouds

7-21. A higher earth temperature than that which would ordinarily occur from direct insolation alone is caused by
1. inversion
2. dispersion
3. the greenhouse effect
4. scattering

7-22. Refer to figure 12-4 in your textbook. The temperature of the earth's surface being heated by the oblique rays is lower than that of the surface being heated by the perpendicular rays because of
1. inversion
2. dispersion
3. absorption
4. scattering

7-23. The sky appears to be blue because of
1. inversion
2. dispersion
3. the greenhouse effect
4. scattering

7-24. Practically all the radiation received in the polar regions during winter is caused by
1. counter-radiation
2. atmospheric radiation
3. terrestrial radiation
4. diffuse sky radiation

7-25. What process prevents the polar regions from becoming progressively colder and the tropical regions from becoming progressively hotter?
1. Radiation
2. Reflection
3. Circulation
4. The greenhouse effect

7-26. The circulation which produces a balance of heat in the Northern Hemisphere is best described as a
1. short tropical column of air bursting at the bottom and moving northward, and a tall polar column breaking off aloft and moving southward
2. short tropical column of air breaking off aloft and moving northward, and a tall polar column bursting at the bottom and moving southward
3. tall tropical column of air bursting at the bottom and moving northward, and a short polar column breaking off aloft and moving southward
4. tall tropical column of air breaking off aloft and moving northward, and a short polar column bursting at the bottom and moving southward

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Learning Objective: Recognize the meaning of basic physics and the composition, forms, properties, and characteristics of matter.

7-27. All matter is composed of which of the following basic particles?
1. Protons and electrons
2. Atoms and molecules
3. Molecules and neutrons
4. Electrons and molecules

7-28. What is the smallest unit into which water can be divided and still retain the characteristics of water?
1. Atom
2. Proton
3. Molecule
4. Electron

7-29. What is the smallest particle in a chemical element?
1. A compound
2. A molecule
3. An element
4. An atom

7-30. A compound is formed from which of the following?
1. A combination of two or more atoms
2. A mixture of elements
3. A mixture of atoms
4. A combination of two or more elements

7-31. Air is an example of which of the following?
1. A mixture
2. An element
3. A compound
4. A substance

7-32. Matter may be found in which of the following states?
1. Gas only
2. Liquid only
3. Solid only
4. Gas, liquid, or solid

Items 7-33 through 7-36 refer to the following general properties of matter:
A. Mass
B. Density
C. Permanence
D. Inertia
E. Specific gravity
F. Impenetrability
G. Weight
H. Porosity
I. Volume
J. Gravitation

7-33. This property remains the same regardless of altitude or latitude.
1. A
2. B
3. G
4. J

7-34. These properties vary with both latitude and altitude.
1. A and B
2. D and E
3. G and I
4. G and J

7-35. This property is the product of three linear measurements.
1. A
2. E
3. G
4. I

7-36. This property of an object is derived by dividing the object's mass by its volume.
1. B
2. D
3. E
4. I

Learning Objective: Identify terms and units of measure employed in the metric system, and solve problems of metric system unit conversion.

7-37. The metric (CGS) system has been adopted by meteorologists to measure units of
1. length, mass, and time
2. gravity, density, and force
3. centimeters, grams, and seconds
4. circular motion, gravity, and speed

7-38. A dekameter is equivalent to approximately how many feet?
1. 3.28 ft
2. 3.93 ft
3. 32.8 ft
4. 39.3 ft

7-39. How many inches are there in 2.5 meters?
1. 0.98425 in.
2. 9.84250 in.
3. 98.42500 in.
4. 984.25000 in.

7-40. Approximately how many inches are there in 25 centimeters?
1. 0.984 in.
2. 9.840 in.
3. 98.400 in.
4. 984.000 in.

7-41. A cube whose volume is 1,000 cubic centimeters is referred to as a
1. cubic liter
2. liter
3. cubic meter
4. centiliter

7-42. The force that applies acceleration to a mass is measured in
1. feet per second
2. dynes
3. meters per second
4. ergs

7-43. Approximately how many kilograms are the equivalent of 24 pounds?
1. 0.996 kg
2. 11.000 kg
3. 19.000 kg
4. 24.000 kg

Learning Objective: Identify how atmospheric pressure is related to acceleration and mass by Newton's second law, the standards of measurement, and the effect of altitude on pressure.

7-44. Newton's second law of motion, $a = \frac{F}{m}$, which can be converted to the form $F = ma$, indicates that
1. force is inversely proportional to the product of the mass of a body and its acceleration
2. acceleration is inversely proportional to the force acting on a body and directly proportional to its mass
3. acceleration is directly proportional to the force acting on a body and inversely proportional to its mass
4. the mass of a body is determined by the sum of its acceleration and the external force acting on it

7-45. One atmosphere of pressure can be expressed as
1. 1,013.25 mb, 760 mm, or 29.92 in. mercury
2. 1,013.3 mb, 29.92 mm, or 7.35 psi
3. 1,033 mm, 760 in. mercury, or 29.9 mb
4. 1,033 mb, 760 psi, or 29.9 mm

In items 7-46 through 7-48, select from column B the atmospheric pressure of each altitude in column A under standard conditions.

	A. Altitudes	B. Pressure Expressions
7-46.	Sea level	1. 500 mb
7-47.	18,000 feet	2. 3.68 psi
7-48.	36,000 feet	3. 760 gm/cm^2
		4. 29.92 in. mercury

7-49. The air pressure upon an aircraft increases as the aircraft
1. climbs
2. descends
3. accelerates
4. turns sharply

7-50. Which of the following has the greatest effect on atmospheric pressure?
1. Altitude
2. Humidity
3. Density
4. Temperature

Learning Objective: Recognize means by which temperature can be measured, scales used to indicate temperature, and the meaning of free air temperature; and solve problems in temperature scale conversions.

7-51. Which methods are normally used for temperature measurements?
1. Changes in electrical resistance, special analyses, and color comparison
2. Changes in electrical resistance, changes in volume of confined substances, and spectral analyses
3. Changes in volume of confined substances, differences in linear expansion of metals, and color comparisons
4. Changes in volume of confined substances, differences in linear expansion of metals, and changes in electrical resistance

7-52. Degrees Celsius represents a wider temperature range than degrees Fahrenheit since a change of 5° C is equal to a change of 9° F. What does a change in temperature of 20° C correspond to in Fahrenheit degrees?
1. 14° F
2. 26° F
3. 36° F
4. 47° F

● In items 7-53 through 7-58, by the use of the proper formula, make the indicated temperature scale conversions.

7-53. 113° F converted to Celisus is
1. 4.4° C
2. 45.0° C
3. 80.5° C
4. 386.0° C

7-54. 40° C converted to Fahrenheit is
1. 4.4° F
2. 54.0° F
3. 104.0° F
4. 313.0° F

7-55. Which is the correct use of the decimal method in converting 36° C to the Fahrenheit temperature scale?
1. 36° X 1.8 = 64.8°; 64.8° - 32° = 32.8° F
2. 36° X 1.8 = 64.8°; 64.8° + 32° = 96.8° F
3. 36° ÷ 1.8 = 20°; 20° - 32° = -12° F
4. 36° ÷ 1.8 = 20°; 20° + 32° = 52° F

7-56. Which of the following is the correct use of the decimal method in converting 68° F to the Celsius temperature scale?
1. 68° - 32° = 36°; 36° ÷ 1.8 = 20° C
2. 68° - 32° = 36°; 36° X 1.8 = 20° C
3. 68° + 32° = 100°; 100° ÷ 1.8 = 55.5° C
4. 68° + 32° = 100°; 100° X 1.8 = 180° C

7-57. 76° C converted to Absolute is
1. 24.4° A (or K)
2. 80.9° A (or K)
3. 197.0° A (or K)
4. 349.0° A (or K)

7-58. 95° F converted to Absolute is
1. 35° A (or K)
2. 203° A (or K)
3. 308° A (or K)
4. 368° A (or K)

Learning Objective: Recognize classifications, characteristics, and phenomena associated with atmospheric zones.

7-59. As a general rule, temperature decreases with altitude. A condition in which the reverse occurs is known as
1. scattering
2. reflection
3. inversion
4. the greenhouse effect

7-60. Which condition exists when temperature remains constant with altitude?
1. Stable
2. Unstable
3. Inversion
4. Isothermal

7-61. All the following atmospheric zones are classified as meteorological except the
1. exosphere
2. stratosphere
3. ozonosphere
4. thermosphere

7-62. Above what area of the earth is the height of the troposphere the greatest?
1. The poles at all times
2. The Equator at all times
3. The midlatitudes
4. The poles in the summer and the Equator in the winter

7-63. All weather occurs in which meteorological zone?
1. Mesosphere
2. Thermosphere
3. Stratosphere
4. Troposphere

7-64. Which of the following statements is correct concerning the tropopause, the boundary between the troposphere and the stratosphere?
1. It is characterized by rapid temperature decreases with altitude
2. It is characterized by rapid temperature increases with altitude
3. It is not continuous from the Equator to the poles
4. It is uniformly thick

7-65. The composition of the air above the tropopause is about the same as that below it with the exception of the amount of
1. oxygen
2. nitrogen
3. water vapor
4. carbon dioxide

7-66. Absorption of ultraviolet radiation by ozone causes an increase in temperature in the
1. exosphere
2. mesophere
3. troposphere
4. stratosphere

7-67. In which layer does the atmospheric temperature decrease to a minimum of about -93° C?
1. The stratosphere
2. The thermosphere
3. The exosphere
4. The mesosphere

7-68. Which atmospheric zone is noted for providing conditions favorable for increased radio propagation?
1. Stratosphere
2. Ozonosphere
3. Ionosphere
4. Mesosphere

Assignment 8

The Governing Fundamentals of Meteorology(Continued:)

Text: Pages 267 - 288

Learning Objective: Recognize the various methods of heat transfer within our environment, including the terms applied to these methods.

8-1. By which methods of heat transfer do low level parcels of air receive heat from the earth?
1. Radiation and advection only
2. Radiation and conduction
3. Radiation and convection only
4. Radiation, convection, and advection

8-2. A cold object touched by a warm object is heated by
1. radiation
2. advection
3. convection
4. conduction

8-3. When a pot of cold water is heated to the boiling point, what two methods of heat transfer are employed?
1. Conduction and radiation
2. Convection and conduction
3. Convection and advection
4. Convection and radiation

8-4. Which method of heat transfer is responsible for the transportation of the greatest amount of heat from one latitude to another?
1. Advection
2. Conduction
3. Convection
4. Radiation

8-5. Which of the following requires the greatest amount of time for either heating or cooling?
1. A dry, sandy area
2. An ocean surface
3. An ice surface
4. A forest area

Learning Objective: Identify the standard conditions relating to gases, the effects of the kinetic theory, and some of the major laws, theorems, and principles affecting gases.

8-6. What are the standard conditions under which gases can be compared, densities determined, and gas constants derived?
1. 0° C temperature and 760 mb pressure
2. 0° C temperature and 760mm pressure
3. 15° C temperature and 1,013.25 mb pressure
4. 15° C temperature and 1,013.25mm pressure

8-7. The pressure of an enclosed gas depends on the
1. number of molecules it contains
2. average space between its molecules
3. force with which its molecules collide with one another
4. number of times its molecules strike the container during a given period of time

8-8. The volume of a gas is inversely proportional to its pressure, provided its temperature remains constant, defines
1. Charles' Law
2. Boyle's Law
3. Equation of State
4. Universal Gas Law

8-9. If the volume of a confined gas is held constant while its temperature is increased, what changes in pressure and molecular speed will take place?
1. Both pressure and molecular speed will decrease
2. Both pressure and molecular speed will increase
3. Pressure will increase and molecular speed will decrease
4. Pressure will decrease and molecular speed will increase

8-10. Charles' Law states that if the volume of an enclosed gas remains constant, the pressure is then directly proportional to the absolute temperature. Therefore, if the absolute temperature is doubled the pressure will be
1. decreased
2. doubled
3. halved
4. quartered

8-11. Which law gives the same information as Charles' Law and Boyle's Law?
1. Pascal's Law
2. Bernoulli's Theorem
3. Equation of State
4. Kenetic Theory of Gases

Learning Objective: Identify the characteristics of moisture and solve related humidity and heat measurement problems.

8-12. Which of the following actions will cause the water vapor in a closed container of saturated air to condense?
1. Reducing the pressure on the mixture
2. Reducing the temperature of the mixture
3. Increasing the pressure on the mixture
4. Increasing the temperature of the mixture

8-13. Assume that a closed container holds a mixture of four gases. If the partial pressures of the individual gases are 3 cm, 14 cm, 26 cm, and 51 cm of mercury respectively, what is the total pressure in the box?
1. 23.5 cm
2. 47.0 cm
3. 51.0 cm
4. 94.0 cm

8-14. At a temperature of 20° C, saturated air contains 17.3 grams of water vapor per cubic meter. Assume that a parcel of air contains 8.65 grams of water per cubic meter at 20° C. What is the percent of saturation of this parcel of air?
1. 10 percent
2. 30 percent
3. 50 percent
4. 80 percent

● In items 8-15 through 8-20, assume there are 785 grams of dry air at 25° C and 1,000 mb pressure in a container having a volume of 1 cubic meter. Also assume that 16.1 grams of water vapor at the same temperature are put into the container.

8-15. What is the relative humidity of the final mixture of air and water vapor in the container?
1. 30 percent
2. 40 percent
3. 60 percent
4. 70 percent

8-16. The absolute humidity of the final mixture of air and water vapor in the container is
1. 6.95 grams per cubic meter
2. 16.1 grams per cubic meter
3. 23.05 grams per cubic meter
4. 39.15 grams per cubic meter

8-17. If an additional 20 grams of water vapor were added to the existing mixture of air and water vapor, what would be the absolute humidity in the container?
1. 3.9 grams per cubic meter
2. 16.1 grams per cubic meter
3. 23.05 grams per cubic meter
4. 36.1 grams per cubic meter

8-18. What is the specific humidity of the final mixture of air and water vapor in the container as given in the preceding item?
1. 0.0201 grams per gram
2. 0.0285 grams per gram
3. 1.08 grams per gram
4. 35.06 grams per gram

8-19. The mixing ratio of the final mixture of air and water vapor as given in the original information is
1. 0.0205 grams per gram
2. 0.161 grams per gram
3. 39.15 grams per gram
4. 785.0 grams per gram

8-20. What is the approximate saturation mixing ratio of this original mixture?
1. 3
2. 30
3. 230
4. 3,300

Learning Objective: Identify types of latent heat and the characteristics of matter as it changes from one state to another.

8-21. How many calories of heat are required to raise the temperature of 1,500 grams of water from 25° C to 85° C?
1. 60 cal
2. 1,500 cal
3. 90,000 cal
4. 127,500 cal

8-22. Which of the following pairs of change of state processes will produce similar results?
1. Melting and fusion
2. Freezing and condensation
3. Melting and evaporation
4. Condensation and evaporation

In items 8-23 through 8-25, select from column B the type of latent heat defined by each statement in column A.

A. Statements	B. Types of Latent Heat
8-23. It is heat that is released when a substance changes from a liquid state to a solid	1. Sublimation 2. Vaporization
8-24. It is heat that is released when a substance changes from a vapor state to a liquid	3. Fusion 4. Condensation
8-25. It is heat that is absorbed when a substance changes from a liquid state to a vapor	

8-26. What is the meteorological term for the process that results when a substance changes directly from a solid to a vapor or directly from a vapor to a solid?
1. Fusion
2. Sublimation
3. Condensation
4. Crystallization

8-27. What term defines the process by which water vapor turns to ice without first becoming a liquid?
1. Sublimation
2. Fusion
3. Condensation
4. Crystallization

Learning Objective: Identify the characteristics of the adiabatic process and the methods of heat transfer, including the computation of air mass temperature differences and lapse rates.

8-28. What causes the temperature of a given volume of air to rise if that volume of air is compressed adiabatically?
1. Heat is absorbed by the air mass through exchange with the environment
2. Additional heat is absorbed by the air mass from the forces causing compression
3. Compression eliminates moisture, thereby allowing the temperature to rise
4. Heat is generated by the work of compression

8-29. When is a lifted parcel of air considered unstable?
1. When it becomes less dense than the surrounding air
2. When it becomes denser than the surrounding air
3. When its density remains the same as the surrounding air
4. When it is forced up a mountain slope

8-30. A mass of air that is unsaturated at a temperature of 75° F is starting to rise from the earth's surface and to cool adiabatically. If it becomes saturated when its temperature falls to 53° F, how high will it be when condensation occurs?
1. 4,000 ft
2. 9,636 ft
3. 12,100 ft
4. 13,636 ft

8-31. A saturated mass of air having a temperature of 38° F is at 6,500 feet and is forced over a 13,500-foot mountain. Condensation occurs from 6,500 to 13,500 feet and falls from the air during ascent. What will be the approximate temperature of this air mass at 6,500 feet as it descends the other side of the mountain?
1. 20.5° F
2. 38.0° F
3. 38.5° F
4. 59.0° F

● In items 8-32 and 8-33 assume that a parcel of air having a temperature of 60° F is at 3,500 feet and is forced over a 14,500-foot mountain. Condensation occurs from 3,500 feet to 14,500 feet so that the parcel cools at the moist adiabatic lapse rate and reaches a temperature of approximately 27° F at the top of the mountain. As the condensation has fallen out of the air during the ascent, the parcel will heat at the dry adiabatic lapse rate as it descends on the other side of the mountain.

8-32. What will be the adiabatic lapse rate of cooling as the air rises?
1. 2° F
2. 3° F
3. 4 1/2° F
4. 5 1/2° F

8-33. When the parcel descends on the other side of the mountain to an altitude of 3,500 feet, its temperature will be approximately
1. 60.0° F
2. 69.5° F
3. 78.5° F
4. 87.5° F

8-34. If the temperature of a parcel of air drops at a rate of 9° F per 1,000 feet, its lapse rate is
1. dry
2. average
3. autoconvective
4. superadiabatic

Learning Objective: Recognize terms, principles, and laws associated with mass, force, and motion, including Newton's laws, pressure gradient force, Coriolis effect, centrifugal force, and centripetal force.

8-35. Which of the following is the correct meteorological phrase used to indicate air movement when both direction and rate of movement are involved?
1. Speed
2. Acceleration
3. Velocity
4. Direction and speed

In items 8-36 through 8-38, select from column B the descriptive term applied to each of Newton's laws of motion in column A.

A. Laws of Motion	B. Descriptive Terms
8-36. First	1. Force and acceleration
8-37. Second	2. Circular motion
8-38. Third	3. Inertia
	4. Reacting forces

8-39. In the metric system, d in the formula $W = Fd$ is measured in which of the following units?
1. Centimeters
2. Joules
3. Dynes
4. Ergs

8-40. What term is used to identify the work accomplished by the force of one dyne which moves a mass a distance of one centimeter?
1. Joule
2. Foot-pound
3. Erg
4. Force-pound

8-41. In the study of atmospheric physics, what type of energy is the energy of motion?
1. Potential energy
2. Kinetic energy
3. Latent energy
4. Dynamic energy

8-42. Air is moved from a high-pressure area to a low-pressure area by the action of the
1. pressure gradient force
2. centrifugal effect
3. Coriolis effect
4. centripetal force

8-43. The wind would blow at right angles across isobars if the only force affecting windflow was the
1. Coriolis force
2. pressure gradient force
3. centripetal force
4. centrifugal force

8-44. Which of the following statements most correctly describes the action of Coriolis effect on air mass?
1. The effect is greatest at the poles, decreases to zero effect at the Equator, and right or left deflection in the intermediate zones depends upon the latitude and speed of the moving air mass
2. The effect is nonexistent at the Equator, increases to maximum effect at the poles, deflects air to the left of its path in the Southern Hemisphere, and to the right of its path in the Northern Hemisphere
3. The intensity of the effect and right or left deflection are dependent upon the speed and temperature of the moving air mass
4. The effect is nonexistent at the Equator, increases to maximum effect at the poles, deflects air to the right of its path in the Southern Hemisphere, and to the left of its path in the Northern Hemisphere

8-45. Which force compels an object to be thrown out from its center of rotation?
1. Centrifugal
2. Gravitational
3. Centripetal
4. Centrical

8-46. Winds flowing in a circular path are influenced by the
1. Coriolis effect, pressure gradient force, and centrifugal effect
2. centripetal effect, Coriolis effect, and pressure gradient
3. centrifugal effect, speed, and centripetal effect
4. Coriolis effect, speed, and centripetal effect

8-47. In accordance with Bernoulli's theorem, the pressure of a flowing gas is
1. directly proportional to its velocity
2. inversely proportional to its velocity
3. always equal to its velocity
4. unaffected by its velocity

Learning Objective: Recognize the characteristics of light, the effects of light striking various substances, the meaning of transparent and opaque as they apply to various substances, the measurement of the intensity of light, the meaning and characteristics of normal, incident, reflected, and diffused rays, and identify atmospheric light-related phenomena.

8-48. The characteristics of light differ from other regions of the electromagnetic spectrum because of light's
1. frequency only
2. speed only
3. wavelength only
4. frequency, speed, and wavelength

8-49. Frequency of a light ray is defined as
1. the distance from the crest of one wave to the crest of the following wave
2. the number of waves passing a given point in a specified time
3. the distance from a point on one wave to a corresponding point on the next wave
4. the distance from the trough of one wave to the trough of the following trough

8-50. Which of the following is most descriptive of the manner in which any substance reacts to light?
1. It absorbs only
2. It reflects only
3. It reflects or absorbs only
4. It transmits, reflects, or absorbs

8-51. An object that passes virtually 100 percent of the light striking it exhibits the property of
1. opacity
2. translucency
3. transparency
4. absorptivity

8-52. When none of the light waves which strike a medium are transmitted, the medium is termed
1. opaque
2. absorbent
3. translucent
4. transparent

8-53. The basic measurement for determining the luminous intensity of a light source is the
1. lumen
2. foot-candle
3. candlepower
4. lumen second

8-54. The imaginary line perpendicular to the mirror at the point where the ray strikes is referred to as the
1. angle of reflection
2. angle of incidence
3. Normal
4. reflected light

8-55. If light strikes a surface at an angle of 45°, at what angle will the light be reflected away from that surface?
1. 90°
2. 60°
3. 45°
4. 30°

8-56. When will light rays bend toward the normal when they pass from one transparent substance to another?
1. When they enter the second substance at an angle of less than 90°
2. When they enter the second substance at an angle of 90° or more
3. When the second substance is more dense than the first
4. When the second substance is less dense than the first

8-57. Refer to figure 12-17 in your textbook. Sunlight glancing from the ripples on a lake is an example of
1. regular reflection
2. diffused reflection
3. specular reflection
4. incident transmission

8-58. What will happen to light rays which enter water at an angle of 90°?
1. They will bend toward the normal
2. They will slow down but remain parallel
3. They will bend away from the normal
4. They will speed up but remain parallel

8-59. When a beam of white light is passed through a prism, the colors of the spectrum are visible due to
1. reflection
2. refraction
3. diffusion
4. diffraction

8-60. A mirage is an optical illusion caused by which of the following?
1. Light reflection
2. Light diffraction
3. Light refraction
4. Light diffusion

8-61. Which of the following mirages would cause a distant image to appear inverted in the sky?
1. Superior
2. Lateral
3. Inferior
4. Vertical

8-62. Beams of light which are especially visible in a hazy or humid atmosphere and appear to diverge from the sun both just before and just after sunrise and sunset are called
1. halos
2. rainbows
3. iridescent rays
4. crepuscular rays

8-63. The interference of light rays from the sun or moon by clouds which are small in comparison to the wavelength of the light rays produces a phenomena called
1. rainbows
2. cloud halos
3. cloud iridescence
4. crepuscular rays

Learning Objective: Relative to the properties of sound, describe how its frequency is measured, elements necessary before sound can be produced, characteristics of sound waves, factors that influence sound velocity in a substance, capabilities of the human ear as a detector, and the application of sound in SONAR operation.

8-64. The frequency of sound is measured in
1. hertz
2. meters per second
3. vibrations per second
4. feet per second

8-65. Which of the following must be present before sound can be produced?
1. A source of sound only
2. A detector to hear the sound only
3. A medium to transmit the sound only
4. A source, a detector, and a transmitter of sound

8-66. The particles of a medium through which a longitudinal sound wave is passing will react in what manner?
1. They will move at right angles to the wave's direction of travel
2. They will move in all directions independent of the wave's direction
3. They will move back and forth along the wave's direction of travel
4. They will remain stationary

8-67. The speed at which sound will pass through a given substance is basically dependent upon what characteristics of the substance?
1. Density and temperature
2. Elasticity and density
3. Elasticity and temperature
4. Density and conductivity

8-68. In addition to density, which of the following factors affect the velocity of sound through sea water?
1. Pressure only
2. Current
3. Temperature only
4. Pressure and temperature

8-69. The pitch of a sound wave is governed by which of the following sound wave characteristics?
1. Frequency
2. Intensity
3. Speed
4. Wavelength

8-70. The pitch of a sound can be described as being

1. high, if it contains many overtones; low, if it contains few overtones
2. low, if the wave is transverse; high, if the wave is longitudinal
3. low, if the frequency is low; high, if the frequency is high
4. high, if the wavelength is long; low, if the wavelength is short

8-71. What unit is used to measure the intensity of sound?

1. Hertz
2. Cycle
3. Decibel
4. Radian

8-72. The sound of the siren of a slow-moving police car is heard some distance away by a listener. As the police car approaches the listener the car increases its speed. The pitch of the siren will appear to the listener to

1. become lower
2. become higher
3. remain the same
4. become lower as the police car approaches, but to become higher as it passes and recedes

Assignment 9

Circulation of the Atmosphere; Air Masses and Frosts

Text: Pages 289 - 322

Learning Objective: Identify types and causes of circulations of the earth's atmosphere.

9-1. The sun's radiation is the primary factor in the production of horizontal and vertical motion of air in the earth's atmosphere, but the horizontal motion is directly caused by the
1. expansion of air as it is warmed
2. contraction of air as it is cooled
3. pressure differential over the earth's surface
4. temperature differential over the earth's surface

9-2. Which type of circulation signifies that air motion was modified by a minor, local, meteorological condition?
1. Secondary
2. Primary
3. General
4. Tertiary

Learning Objective: Recognize characteristics and effects of temperature, pressure, earth rotation, and wind on the general circulation of the atmosphere.

9-3. Where and when do the steepest temperature gradients occur?
1. In the middle and high latitudes of each hemisphere in summer
2. In the middle and high latitudes of each hemisphere in winter
3. In the tropical and subtropical latitudes of each hemisphere in winter
4. In the tropical and subtropical latitudes of each hemisphere in summer

9-4. Refer to figure 13-1 in your textbook. Approximately how much do the January and July mean temperatures vary in the area of 40° N, 80° W?
1. 12°
2. 24°
3. 48°
4. 72°

9-5. The polar regions are dominated by areas of
1. high pressure throughout the entire year
2. low pressure throughout the entire year
3. high pressure in the summer, and low pressure in the winter
4. low pressure in the summer, and high pressure in the winter

9-6. What might be concluded about the earth if, without variation, the wind circulation was always due poleward aloft and directly opposite at the surface?
1. The earth is a uniform, rotating sphere
2. The earth is a uniform, nonrotating sphere
3. The earth is a nonuniform, rotating sphere
4. The earth is a nonuniform, nonrotating sphere

9-7. How does the Coriolis force affect windflow?
1. It causes wind deflection to the right in both the Northern and Southern Hemispheres
2. It causes wind deflection to the left in both the Northern and Southern Hemispheres
3. It causes wind deflection to the left in the Northern Hemisphere and to the right in the Southern Hemisphere
4. It causes wind deflection to the right in the Northern Hemisphere and to the left in the Southern Hemisphere

9-8. According to the 3-cell theory, in what vertical direction does air move at latitudes of 0°, 30°, 60°, and 90° in the Northern Hemisphere?
1. Down at 0° and 60°; up at 30° and 90°
2. Down at 30° and 60°; up at 0° and 90°
3. Down at 30° and 90°; up at 0° and 60°
4. Down at 60° and 90°; up at 0° and 30°

In items 9-9 through 9-11, select from column B the general direction of airflow in each Northern Hemisphere circulation cell listed in column A.

A. Circulation	B. Airflow Directions
9-9. Tropical	1. Poleward at the surface, equatorward aloft
9-10. Midlatitude	
9-11. Polar	2. Poleward aloft, equatorward at the surface
	3. Poleward aloft and at the surface
	4. Equatorward aloft and at the surface

9-12. Excessive precipitation is characteristic of the region of the doldrums because of the region's
1. low temperatures and divergent winds
2. high temperatures and divergent winds
3. low temperatures and convergent winds
4. high temperatures and convergent winds

9-13. Refer to figure 13-4 in your textbook. The horse latitudes are bounded by the
1. doldrums on the polar side, and the trade winds on the equatorial side
2. trade winds on the polar side, and the doldrums on the equatorial side
3. prevailing westerlies on the polar side, and the trade winds on the equatorial side
4. polar easterlies on the polar side, and the prevailing westerlies on the equatorial side

9-14. Which of the following factors affecting wind direction and speed is due to the curvature of the isobars?
1. Pressure gradient force
2. Centrifugal effect
3. Frictional force
4. Coriolis effect

9-15. A wind that is blowing parallel to curved isobars in a steady horizontal motion is termed a/an
1. gradient wind
2. isallobaric wind
3. geostrophic wind
4. cyclostrophic wind

9-16. Why do winds at high altitudes tend to move faster than surface winds?
1. The frictional force is weaker at high altitudes
2. The pressure force is stronger at high altitudes
3. The Coriolis effect is stronger at high altitudes
4. The Coriolis effect is weaker at high altitudes

9-17. Which of the following has the greatest effect upon surface wind direction?
1. Friction force
2. Pressure gradient force
3. Coriolis effect
4. Centrifugal effect

9-18. Cyclostrophic wind is the wind that results when the
1. Coriolis effect and centrifugal effect are in balance
2. pressure gradient force is balanced by the Coriolis effect
3. pressure gradient force is balanced by the centrifugal effect
4. centrifugal effect, pressure gradient force, and Coriolis effect become balanced

9-19. Which of the following conditions is generally associated with an area of divergence?
1. Precipitation
2. High barometric pressure
3. Upward flow of air currents
4. Inward flow of air currents

Learning Objective: Recognize the effect of environmental factors on climatic conditions throughout the world.

In items 9-20 through 9-23, select from column B the northernmost boundary of each astronomical zone listed in column A.

	A. Zones	B. Boundaries
9-20.	Torrid	1. Antarctic Circle
9-21.	North Temperate	2. Arctic Circle
9-22.	South Temperate	3. Tropic of Cancer
9-23.	South Polar	4. Tropic of Capricorn

9-24. Which climatic control(s) is/are most important in determining the climate of a region?

1. Altitude
2. Latitude
3. Ocean currents
4. Mountain barriers

In items 9-25 through 9-28, select from column B the location on the earth that receives the most perpendicular rays of the sun on each date listed in column A.

	A. Dates	B. Locations
9-25.	21 March	1. 23 1/2° S lat
9-26.	21 June	2. Equator
9-27.	22 September	3. 23 1/2° N lat
9-28.	22 December	

9-29. What is the principal reason for the temperature range of ocean areas being less than that of continental areas over a given period of time?

1. Heat from water is released more evenly than from the land
2. Heat losses or gains are widely distributed because of the constant motion of water
3. Because of the ocean's greater specific heat, water will absorb more heat than land for the same rise in temperature
4. Because of the ocean's surface uniformity, water will reflect more heat than land for the same rise in temperature

9-30. Rome and New York are at approximately the same latitude, yet Rome has a much milder winter climate. What factor is MOST responsible for this?

1. The prevailing westerlies
2. The east-west orientation of the Alps Mountains
3. The Mediterranean Sea surrounding Italy on three sides
4. The north-south orientation of the Apennines Mountains

9-31. When the movement of an air mass is blocked by a mountain range, the weather element that is most affected is

1. pressure
2. wind velocity
3. precipitation
4. mean daily temperature

9-32. At which of the following altitudes in the trade wind zone does the greatest amount of rainfall occur?

1. Sea level
2. 3,000 ft
3. 6,000 ft
4. 10,000 ft

9-33. What is the principal cause of the ocean currents?

1. The prevailing winds
2. The rotation of the earth
3. The gravitational pull of the sun and the moon
4. The unequal temperatures of the high and low latitudes

Learning Objective: Relative to secondary circulations, indicate the effects of their center of action and identify causes, types, locations, and terms associated with migratory systems including characteristics of monsoons and jetstreams.

9-34. The Atlantic and Pacific highs are most pronounced in which season of the year?

1. Winter
2. Spring
3. Autumn
4. Summer

9-35. The largest individual circulation cell in the Northern Hemisphere during the winter is the

1. Greenland high
2. Bermuda high
3. Asiatic high
4. Pacific high

9-36. Rapidly changing weather conditions throughout all seasons are produced in the midlatitudes by
1. migratory wind systems
2. cyclostrophic wind systems
3. geostrophic and gradient wind systems
4. stationary or quasi-stationary wind systems

9-37. A counterclockwise circulation of air in the Southern Hemisphere is known as a/an
1. cyclone
2. tornado
3. hurricane
4. anticyclone

9-38. What designation is given to a migratory system whose winds blow clockwise and slightly across isobars toward its center, and where will it be found?
1. A cyclone in the Southern Hemisphere
2. A cyclone in the Northern Hemisphere
3. An anticyclone in the Southern Hemisphere
4. An anticyclone in the Northern Hemisphere

9-39. The word cyclolysis refers to the
1. first stage in the development of a cyclone
2. intensification of an existing cyclone
3. decrease and extinction of a cyclone
4. formation of a new cyclone

9-40. In which season of the year does the monsoon wind blow toward large land areas?
1. Fall
2. Winter
3. Spring
4. Summer

9-41. What causes the almost constant rains that are associated with the summer monsoons?
1. Warming of moist air due to mechanical lifting
2. Cooling of moist air due to downslope motion
3. Warming of moist air due to downslope motion
4. Cooling of moist air due to mechanical lifting

9-42. Which of the following statements concerning the jetstream is correct?
1. It is stronger in summer than in winter
2. It increases indefinitely in intensity with elevation
3. Its winds can vary in speed from 50 knots to more than 250 knots
4. It is always found at the same latitude and elevation all around the earth at the same time

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Learning Objective: Identify characteristics of tertiary circulations.

9-43. How do the day and night temperatures of land areas compare with those of water areas?
1. Land areas are warmer during both day and night
2. Land areas are cooler during both day and night
3. Land areas are warmer during the day and cooler at night
4. Land areas are cooler during the day and warmer at night

9-44. In what overall direction do local winds tend to blow during the day and night in areas where large bodies of water and land meet?
1. From water to land during both day and night
2. From land to water during both day and night
3. From land to water during the day and from water to land at night
4. From water to land during the day and from land to water at night

9-45. At what times of the year are land breezes most pronounced?
1. Late fall and early winter
2. Late winter and early spring
3. Late spring and early summer
4. Late summer and early fall

9-46. Refer to figure 13-13 in your textbook. Air movement at night in a valley between mountains is characterized by
1. a warm updraft in the center
2. warm updrafts along upslopes
3. cool updrafts along upslopes
4. a cool downdraft in the center

9-47. Which type of wind flows from a valley area up mountain slopes?
1. Foehn
2. Glacier
3. Anabatic
4. Katabatic

9-48. Chinook winds are warm because of the
1. expansion of ascending air
2. expansion of descending air
3. contraction of ascending air
4. compression of descending air

9-49. The Santa Ana wind of southern California is a good example of a
1. glacier wind
2. funnel effect
3. foehn effect
4. katabatic wind

9-50. Which type of tertiary circulation is characterized by a descending cold, dry wind?
1. Foehn wind
2. Glacier wind
3. Anabatic wind
4. Katabatic wind

9-51. Why are the leeward sides of steep mountains more dangerous to aircraft than the windward sides?
1. Updrafts are more pronounced on the leeward sides
2. Friction is more pronounced on the leeward sides
3. Eddies tend to be more stationary on the leeward sides
4. Downdrafts are accompanied by more pronounced eddies on the leeward sides

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Learning Objective: Recognize the conditions that identify air masses and the relationship of air mass classifications and source regions.

9-52. Which of the following terms is most descriptive of the conditions of moisture and temperature distribution in a body of air that causes it to be called an air mass?
1. Stable
2. Homogeneous
3. Unstable
4. Heterogeneous

9-53. Air masses which are classified S are found over the
1. frozen polar seas
2. frozen polar land areas
3. southwestern United States
4. land areas near the Equator

9-54. A cPk air mass differs from a cPw air mass in that it
1. originates in polar regions
2. originates over a continent
3. is colder than the underlying surfaces
4. is warmer than the underlying surfaces

9-55. Which of the following conditions is most favorable for air mass formation?
1. Rapid motion of a body of air over a uniform surface
2. Stagnation of a body of air over a nonuniform surface
3. Rapid motion of a body of air over a surface of uniform temperature and humidity
4. Stagnation of a body of air over a uniform surface of uniform temperature and humidity

9-56. Which of the following air mass source regions is most closely associated with the great desert areas of the world?
1. cP
2. mP
3. cT
4. mT

9-57. What type of air mass has its source only in the region between 10° N lat and 10° S lat?
1. T
2. A
3. P
4. E

Learning Objective: Identify factors which contribute to air mass modification, and relate associated weather conditions.

9-58. Unstable air is characterized by
1. clear skies
2. radiation fog
3. convective clouds
4. stratiform clouds

9-59. Which of the following air masses is the coldest?
1. Arctic cA
2. Arctic mP
3. Antarctic mP
4. Antarctic cA

9-60. What is generally the effect of the movement of a cP air mass over a warmer land surface?
1. Fog
2. Clear skies
3. Cumuliform clouds
4. High relative humidity

9-61. A cPk air mass that flows over the Gulf of Mexico in winter may be modified to a/an
1. E air mass
2. cT air mass
3. mP air mass
4. mT air mass

9-62. What is the most prevalent air mass in the Southern Hemisphere?
1. mT
2. mP
3. cP
4. E

9-63. Atlantic mTw air moving northward over a land surface in winter is characterized by the nighttime occurrence of
1. fog and stratus clouds
2. cumuliform clouds
3. thunderstorms
4. showers

9-64. During winter, all of the following types of air masses are found over continental North America except
1. S
2. cT
3. mT
4. cPk

9-65. Low stratiform clouds in the morning, convective clouds during the day, and frequent thunderstorms at night are typical conditions of the east coast of the United States in summer and are the result of the predominance of
1. mT air
2. mP air
3. cT air
4. E air

9-66. What is the hottest air mass on record?
1. Australian cT
2. North African cT
3. South American E
4. Southeast Asian mT

Assignment 10

Air Masses and Fronts; Meteorological Elements

Text: Pages 322 - 355

Learning Objective: Recognize the relationship between fronts and air masses, and identify types of fronts and weather conditions associated with each type.

10-1. Which of the following air mass properties is conservative with respect to dry adiabatic temperature changes but is nonconservative with respect to moist adiabatic temperature changes?
1. Temperature
2. Potential temperature
3. Wet-bulb temperature
4. Potential wet-bulb temperature

10-2. Which two properties are conservative relative to both dry and moist adiabatic temperature changes?
1. equivalent potential temperature and relative humidity
2. wet-bulb temperature and relative humidity
3. wet-bulb temperature and potential wet-bulb temperature
4. equivalent potential temperature and potential wet-bulb temperature

10-3. Which of the following phrases best defines the term "front"?
1. The boundary between air masses
2. The centers of action of air masses
3. The regions of transition between air masses
4. The zone of convergence of air masses

10-4. The most important region of transition between two air masses over the United States is the
1. ITCZ
2. doldrums
3. polar front
4. Antarctic front

10-5. A line of discontinuity at the earth's surface along which warm air is displaced by cold air is known as
1. a cold front
2. a warm front
3. a stationary front
4. an occluded front

10-6. The passage of a cold front is accompanied by
1. rising pressure
2. increasing humidity
3. increasing temperature
4. constant wind direction

In items 10-7 through 10-9, select from column B the type of front associated with each movement of warm air described in column A.

A. Warm Air Movements	B. Fronts
10-7. A descending motion of warm air along the frontal surface at high levels, with warm air near the surface being pushed upward vigorously	1. Slow-moving cold front 2. Warm type occlusion
10-8. An advancing warm air mass replacing a retreating colder air mass	3. Fast-moving cold front 4. Warm front
10-9. A general upglide of warm air along the entire frontal surface, with pronounced lifting along its lower portion	

10-10. The passage of which type of front is usually accompanied by a relatively narrow but often violent band of weather?
1. Warm front
2. Stationary front
3. Slow-moving cold front
4. Fast-moving cold front

10-11. Steady precipitation in advance of a warm front is associated with which type of clouds?
1. Cirrus
2. Nimbostratus
3. Altostratus
4. Cirrostratus

10-12. Which of the following fronts develops when a cold front overtakes a warm front and the coldest air is ahead of the warm front?
1. Warm type occlusion
2. Cold type occlusion
3. Upper warm front
4. Stationary front

10-13. Drizzle from stratiform clouds in a stationary front is associated with
1. stable warm air
2. stable cold air
3. unstable cold air
4. unstable warm air

Learning Objective: Relative to frontal movement, recognize the effects of zone pressures and cyclonic movement of air in relation to fronts, including the influence of speed, outside air masses, and surface conditions.

10-14. What types of pressure and air motion are associated with frontal zones?
1. Low pressure and convergent air
2. Low pressure and divergent air
3. High pressure and divergent air
4. High pressure and convergent air

10-15. Every moving cyclone usually has two significant lines of convergence which are distinguished by their thermal properties. One of these, the warm front, is the discontinuity line that is located
1. in the rear portion of the cyclone where cold air displaces warm air
2. on the forward side of the cyclone where warm air replaces cold air
3. in the rear portion of the cyclone where warm air replaces cold air
4. on the forward side of the cyclone where cold air displaces warm air

10-16. How does the weather produced by a slow-moving front compare in severity and duration with the weather produced by a rapidly moving front?
1. It is more severe and lasts longer
2. It is less severe but lasts longer
3. It is less severe and does not last as long
4. It is more severe but does not last as long

10-17. When maritime polar air is moving with a strong westerly wind current and maritime tropical air is moving with a strong southerly wind current, overrunning of the tropical air by the polar air may occur. This generally results in
1. drizzle and rain
2. clear skies
3. heavy showers and violent thunderstorms
4. heavy stratified cloud development

10-18. A cold front that encounters colder stagnant air after passing a mountain range becomes
1. a warm front
2. an occluded front
3. an upper cold front
4. a stationary front

10-19. What effect does a mountain range have on the passage of a warm front?
1. It decreases precipitation on both sides
2. It increases precipitation on both sides
3. It decreases precipitation on the windward side and increases it on the leeward side
4. It increases precipitation on the windward wide and decreases it on the leeward side

10-20. The east coast of the United States has much cloudiness and precipitation in winter because of
1. cold fronts moving out and over warm currents of water
2. warm fronts moving out and over cold currents of water
3. the meeting of continental cold fronts and maritime warm fronts
4. the meeting of the cold currents of water from the polar regions with the warm currents of water from the Equator

10-21. A front moving from the west over the Rocky Mountains will be regenerated on the eastern side if it encounters
1. cold, moist air
2. cold, dry air
3. warm, moist air
4. warm, dry air

10-22. If moist air is not brought into the situation, frontal systems moving from water to land will tend to become
1. modified
2. dissipated
3. regenerated
4. intensified

Learning Objective: Recognize the characteristics, classifications, and formative stages in the development of tropical systems.

10-23. Tropical waves move westward at an average speed of 10 to 15 knots and slope eastward with height reaching a maximum intensity between
1. 850 to 500 mb
2. 700 to 300 mb
3. 700 to 500 mb
4. 850 to 300 mb

10-24. The Inverted-V formation type tropical wave is best defined in the
1. eastern and central North Atlantic
2. eastern and central North Pacific
3. western and central North Atlantic
4. western and central North Pacific

10-25. The forced convergence necessary for the development of the individual cloud system in the ITCZ is caused by a combination of friction and
1. anticyclogenesis
2. cyclogenesis
3. high-level cyclonic wind shear
4. low-level cyclonic wind shear

10-26. When does the precipitation intensity on the ITCZ reach a maximum?
1. Just before dawn
2. Just after dawn
3. Just before noon
4. Just after sunset

10-27. The widest band of cloud cover associated with the ITCZ is found in the
1. Atlantic Ocean
2. Indian Ocean
3. Pacific Ocean
4. Gulf of Mexico

10-28. In what way, if any, do tropical cyclones differ from tornadoes?
1. Tornadoes have lower wind velocities, are of shorter duration, and affect less area
2. Tornadoes have higher wind velocities, are of shorter duration, and affect less area
3. Tornadoes have higher wind velocities, affect less area, and are of longer duration
4. There is no difference except in the geographic location of storm

10-29. The various types of circular low-pressure areas found in the Tropics are classified according to their
1. maximum wind speed
2. point of origin
3. center of pressure
4. temperature

In items 10-30 through 10-32, select from column B the tropical cyclone stage identified with the occurrence of each event listed in column A.

A. Events

10-30. The transformation of the storm into an extratropical cyclone

10-31. The appearance of westerly winds in low tropical latitudes where easterly winds normally prevail

10-32. The organization of the wind system into a tight, symmetrical ring around the eye

B. Stages

1. Formative
2. Immature
3. Mature
4. Decaying

10-33. A tropical cyclone has reached which stage when it assumes the characteristics of an extratropical cyclone?
1. Formative
3. Immature
3. Mature
4. Decaying

10-34. The strongest winds of a tropical cyclone in the Northern Hemisphere are usually found in which section of the storm?
1. Left semicircle
2. Right semicircle
3. Left rear quadrant
4. Right rear quadrant

10-35. Where does the rapid, significant drop in barometric pressure associated with tropical cyclones begin?
1. Three hours before the storm
2. Well in advance of the storm
3. On the outer edge of the right front quadrant of the storm
4. On the outer edge of the left rear quadrant of the storm

10-36. What are the most important cloud types found within a tropical cyclone?
1. Precipitation mid-clouds
2. The advance cirrus and cirrostratus
3. Heavy cumulus and cumulonimbus
4. All species of low clouds

10-37. One characteristic of the eye of a tropical cyclone is a sudden
1. decrease in wind speed
2. decrease in temperature
3. increase in the amount of clouds
4. increase in the intensity of precipitation

10-38. Which of the following is a well-known sign that appears in the open sea far in advance of an approaching tropical cyclone?
1. Long, low, heavy swells
2. Rapid decrease in pressure
3. Gradual decline in wind speed
4. Line of heavy cumulonimbus clouds

10-39. In the Gulf of Mexico and the Caribbean Sea, a good indication of a hurricane is long swell waves with a period of
1. 9 to 15 seconds
2. 9 to 12 seconds
3. 10 to 20 seconds
4. 12 to 15 seconds

10-40. Unless a tropical cyclone is unusually well-developed, the 200-mb level is marked by
1. cyclonic inflow
2. anticyclonic inflow
3. cyclonic outflow
4. anticyclonic outflow

In items 10-41 through 10-45, select from column B the dates of highest frequency of tropical cyclone formation in the areas in column A.

	A. Areas	B. Dates
10-41.	Gulf of Mexico	1. Jan, Feb, Mar
10-42.	Coral Sea and west of Tuamotu Islands	2. June through Nov
10-43.	Marshall, Caroline, and Phillipine Islands and China Sea	3. July, Aug, Sep, Oct
		4. Aug, Sep, Oct
10-44.	Bay of Bengal	
10-45.	Western Caribbean	

Learning Objective: Identify meteorological elements by type, classification, physical makeup, and/or origin.

10-46. The most dominant meteorological element controlling the type and intensity of weather is
1. wind
2. pressure
3. water vapor
4. temperature

10-47. What term applies to liquid, freezing, or solid precipitation and water particles?
1. Lithometeors
2. Hydrometeors
3. Igneous meteors
4. Luminous meteors

10-48. All of the following hydrometeors are forms of precipitation except
1. dew
2. snow
3. sleet
4. drizzle

10-49. Sometimes referred to as mist, very small and uniformly dispersed droplets that appear to float in the air defines which of the following phenomena?
1. Drizzle
2. Rain
3. Dew
4. Snow

10-50. The type of precipitation that was formerly referred to as sleet, now is called
1. ice prisms
2. glaze
3. ice pellets
4. rime

10-51. What type of frozen precipitation is associated with thunderstorm activity?
1. Ice pellets
2. Hail
3. Snow
4. Snow grains

10-52. The primary difference between drifting snow and blowing snow is
1. a ten knot difference in the wind speed
2. the height above ground that the particles are lifted
3. the visibility with blowing snow is greater
4. the size of the particles that are moved by the wind

10-53. Accretion is the process by which water droplets do which of the following?
1. Evaporate and then sublimate directly into ice crystals
2. Sublimate into ice crystals because of air turbulence
3. Grow in size by continuing condensation
4. Accumulate more layers by colliding with and holding smaller droplets

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Learning Objective: Recognize how clouds are formed, their classification according to composition, appearance, and size, and identify precipitation associated with certain types of clouds.

10-54. Clouds form most commonly as the direct result of
1. condensation
2. evaporation
3. sublimation
4. crystallization

10-55. Refer to the preceding item. In order for this to occur, three conditions must be met. These conditions include the presence of all the following EXCEPT
1. wind
2. moisture
3. a cooling process
4. hygroscopic nuclei

In items 10-56 through 10-58, select from column B the condensation inducing cooling process which applies to each condition in column A.

	A. Conditions	B. Cooling Processes
10-56.	Two masses of air with different densities meet, and the mass having less density moves up and over the mass having the greater density	1. Convective 2. Radiational 3. Mechanical 4. Orographic
10-57.	A mass of air in contact with the surface is cooled to its dewpoint by contact cooling	
10-58.	A limited mass of air is heated on the surface and ascends through the atmosphere until its temperature is equal to, or less than, that of the surrounding air	

In items 10-59 through 10-61, select from column B the class of cloud that is confined in each etage listed in column A.

	A. Etages	B. Classes of Clouds
10-59.	High	1. Altocumulus
10-60.	Middle	2. Cirrocumulus
10-61.	Low	3. Cumulus
		4. Stratocumulus

10-62. What cloud genera abbreviation is associated with clouds described as sheep-back-like clouds?
1. AC
2. CB
3. CC
4. SC

10-63. Altocumulus, stratocumulus, and occasionally cirrocumulus clouds which are spread out in an extensive horizontal sheet or layer are identified as what species?
1. Castellanus
2. Fractus
3. Uncinus
4. Stratiformis

10-64. For classification purposes, clouds are divided into etages, genera, species, and varieties. Variety refers to a cloud's
1. height
2. description
3. size
4. transparency

10-65. Clouds described as detached, delicate, with a fibrous appearance are identified as
1. Cirrostratus
2. Fractostratus
3. Cirrus
4. Stratocumulus

10-66. The ice crystal composition of a cirrus cloud determines which characteristic of this high etage cloud?
1. Shape
2. Height
3. Transparency
4. Size

10-67. What type clouds are associated with the term mackerel sky?
1. Cirrostratus
2. Cumulonimbus
3. Stratocumulus
4. Cirrocumulus

10-68. What type clouds exist in several varieties but are not divided into any species?
1. Stratocumulus
2. Cirrostratus
3. Nimbostratus
4. Altostratus

10-69. Either continuous rain or snow is the form of precipitation that results from
1. stratocumulus clouds
2. stratus clouds
3. nimbostratus clouds
4. altostratus clouds

10-70. Vertical development is indicative of which cloud genera?
1. Cumulus and cumulonimbus
2. Stratus and nimbostratus
3. Cumulonimbus and stratus
4. Altostratus and cumulus

10-71. A flat or anvil top is characteristic of
1. cumulus clouds
2. stratocumulus clouds
3. cumulonimbus clouds
4. stratus clouds

10-72. Heavy, intermittent showers, sometimes mixed with hail, are a characteristic form of precipitation of which type clouds?
1. Altostratus
2. Cumulonimbus
3. Nimbostratus
4. Stratus

Assignment 11

Meteorological Elements; Fundamental Oceanography

Text: Pages 357 - 380

Learning Objective: Relate air mass saturation, temperature, and dewpoint to fog formation, and identify composition and types of fog and conditions applicable to the formation of each type.

11-1. Assume that two masses of air contain the same percentage of water vapor and that both are at the same pressure. Mass A is at a higher temperature than mass B. The temperature of each mass is lowered by the same amount and mass A reaches its dewpoint due to the temperature drop. How does this drop in temperature affect mass B?

1. Mass B is cooled below its dewpoint and some of its water vapor condenses
2. Mass B approaches saturation but no water vapor condenses
3. Mass B is not cooled below its dewpoint, hence no water vapor condenses
4. All the water vapor in mass B condenses

11-2. Assume that two masses of air are at the same temperature and pressure, but that mass A is more nearly saturated with water vapor than mass B. What may be concluded about the dewpoints of the two masses?

1. The dewpoint of mass B is higher than that of mass A
2. The dewpoint of mass A is higher than that of mass B
3. The dewpoints of masses A and B are the same
4. The dewpoints of masses A and B are different, but not enough information is given to determine which is higher

11-3. Which of the following will result in the saturation of an air mass?

1. Rising dewpoint
2. Lowering humidity
3. Lowering dewpoint
4. Rising temperature

11-4. Which of the following types of fog forms only over land during nighttime?

1. Advection fog
2. Radiation fog
3. Land advection fog
4. Steam fog

11-5. Radiation fog is common in areas characterized by

1. high pressure, low wind speed, and clear skies
2. low pressure, low wind speed, and cloudy skies
3. high pressure, high wind speed, and cloudy skies
4. low pressure, high wind speed, and clear skies

11-6. Fog that is produced when warm air is transported over a cooler surface is called

1. upslope fog
2. frontal fog
3. advection fog
4. radiation fog

11-7. Sea fog is formed when the wind brings

1. dry warm air over a colder ocean
2. moist warm air over a colder ocean
3. moist cool air over a warmer ocean
4. dry cool air over a warmer ocean

11-8. Land advection fog may be caused by any of the following conditions EXCEPT

1. warm air being forced up a slope by the wind
2. an onshore breeze bringing maritime air over a land surface which has cooled off by radiation at night
3. fog being formed over the ocean and blown over the land during either day or night
4. air flowing from warm, bare ground to snow-covered ground nearby

11-9. When the dewpoint is raised, which type of fog is formed?
1. Sea fog
2. Steam fog
3. Land advection fog
4. Radiation fog

11-10. What processes are taking place when an upslope fog is forming?
1. Air is rising, expanding, and cooling
2. Air is rising, contracting, and cooling
3. Air is descending, expanding, and cooling
4. Air is descending and being warmed by contraction

11-11. Frontal fogs are formed as the result of the
1. condensation of water vapor from the surrounding air
2. transportation of warm air over a colder land or water surface
3. radiational cooling of the earth's surface
4. evaporation of falling rain

11-12. Which type of fog is considered to be the most dangerous?
1. Cold-front fog
2. Upslope fog
3. Sea fog
4. Warm-front fog

Learning Objective: Identify hydrometeors that are deposited on objects at, or near, the ground.

In items 11-13 through 11-15, select from column B the hydrometeor that is applicable to each description in column A.

A. Description	B. Hydrometeors
11-13. Crystalline appearing ice deposited directly on objects at, or near, the ground	1. Dew
11-14. Solid equivalent of waterdrops deposited on objects at, or near, the ground resulting from condensation of water vapor from clear air	2. White dew
11-15. Dew which is frozen after it forms	3. Frost

Learning Objective: Recognize the weather conditions associated with most tornado activity, tornado forecast possibilities, and the incidence of tornado activity as related to the time of year.

11-16. Generally, what is the horizontal speed of a tornado?
1. 150 to 300 mph
2. 50 to 100 mph
3. 25 to 40 mph
4. 5 to 15 mph

11-17. The season for maximum tornado occurrence in the United States is late
1. summer and early fall
2. fall and early winter
3. spring and early summer
4. winter and early spring

11-18. Where is a tornado most likely to be developed?
1. Along a warm front
2. Behind a squall line
3. In advance of a cold front
4. In the trough of an occluded front

11-19. Which of the following conditions would NOT be associated with tornado activity?
1. A rapidly moving cold front
2. A dry air mass superimposed on a moist air mass
3. Pronounced change of wind velocity with distance
4. A cold air mass superimposed on a dry air mass

Learning Objective: Recognize causes and effects of lithometeors, photometeors, and electrometeors.

11-20. Which lithometeor causes the sun to appear red at sunrise and sunset and to have an orange glow during the daytime?
1. Haze
2. Dust
3. Sand
4. Smoke

11-21. All but which of the following photometeors indirectly affect weather through their relationship to clouds?
1. Halos
2. Coronas
3. Auroras
4. Rainbows

In items 11-22 through 11-24, select from column B the photometeor which results from each condition listed in column A.

	A. Conditions	B. Photometeors
11-22.	The diffraction of light by water droplets	1. Halo 2. Corona
11-23.	The diffraction, refraction, and reflection of light within raindrops	3. Rainbow 4. Fogbow
11-24.	The refraction of light as it passes through ice crystals	

11-25. All the following luminous phenomena result from atmospheric electricity EXCEPT
1. fogbows
2. the aurora borealis
3. lightning
4. airglow

Learning Objective: Relative to thunderstorms, describe their formation and structural stages, associated weather conditions, classification, detection and tracking, and procedures relating to the operation of aircraft in their vicinity.

11-26. The atmospheric conditions necessary for the formation of a thunderstorm include a combination of conditionally
1. stable air of relatively low humidity and some type of lifting action
2. stable air of relatively high humidity and some type of subsiding action
3. unstable air of relatively low humidity and some type of subsiding action
4. unstable air of relatively high humidity and some type of lifting action

11-27. What are the three distinct stages of a thunderstorm in the order of the thunderstorm's life cycle?
1. Anvil, mature, and convective
2. Convective, anvil, and mature
3. Cumulus, mature, and dissipating
4. Mature, dissipating, and cumulus

11-28. At what stage in the life cycle of a thunderstorm do surface rains begin to fall?
1. Anvil
2. Mature
3. Cumulus
4. Convective

11-29. The downdrafts of the thunderstorm cycle are initiated by the
1. frictional drag of rainfall
2. evaporative cooling of the air
3. adiabatic cooling of the air
4. warming of the upper air by condensation

11-30. The most rapid vertical air movement of a thunderstorm occurs in the
1. updrafts of the mature stage
2. downdrafts of the mature stage
3. updrafts of the cumulus stage
4. downdrafts of the dissipating stage

11-31. In which stages of a thunderstorm are downdrafts significant?
1. Anvil, dissipating, and cumulus
2. Cumulus and anvil only
3. Cumulus and mature
4. Mature and anvil

11-32. How are thunderstorm turbulence and precipitation related?
1. As precipitation increases, turbulence tends to decrease
2. As turbulence increases, precipitation tends to decrease
3. As precipitation increases, turbulence tends to increase
4. They have little effect on one another

11-33. The total wind speed observed at the surface as a storm cell approaches is the result of
1. updraft divergence only
2. downdraft divergence only
3. updraft divergence plus the forward velocity
4. downdraft divergence plus the forward velocity

11-34. The first gust of a thunderstorm is characterized by a/an
1. rapid decrease in pressure
2. onset of light rain
3. rapid decrease in temperature
4. sudden change in wind direction and speed

11-35. Which of the following types of thunderstorms occurs when a wedge of cold air moves into a body of warm, moist, unstable air?
1. Air-mass
2. Cold-front
3. Convective
4. Orographic

11-36. Heating of the air by the underlying surface may result in the development of a
1. prefrontal thunderstorm
2. convective thunderstorm
3. warm-front thunderstorm
4. squall-line thunderstorm

11-37. Convective thunderstorms that occur over bodies of water usually form during the
1. early evening and dissipate in the late morning
2. late afternoon and dissipate in the early morning
3. early morning and dissipate in the late afternoon
4. late afternoon and dissipate in the early evening

11-38. Where do orographic thunderstorms form?
1. In mountainous areas
2. Over large bodies of water
3. Over low, relatively flat land
4. Over lowlands near large bodies of water

11-39. From a station, which of the following is the most accurate means of tracking the movements of a thunderstorm?
1. Making reconnaissance flights
2. Plotting 3-hourly synoptic charts
3. Using radar with PPI presentations
4. Checking airways sequence reports

11-40. A luminous phenomenon which appears in the high atmosphere in the form of arcs or bands is referred to as
1. lightning
2. an airglow
3. cloud discharges
4. an aurora

Learning Objective: Define specific oceanographic related terms and phrases, and identify ocean bottom topography.

In items 11-41 through 11-43, select from column B the oceanographic related term or phrase identified by each definition in column A.

	A. Definitions	B. Terms and Phrases
11-41.	The loss of sound energy due to absorption and scattering	1. Air-sea interface
		2. Absorption
11-42.	The reduction of sound intensity through the conversion of sound energy into heat due to friction of dense water	3. Attenuation
		4. Thermocline
11-43.	The boundary where the ocean's surface and the earth's atmosphere meet	

In items 11-44 through 11-47, select from column B the definition of each oceanographic related term or phrase in column A.

	A. Terms and Phrases	B. Definitions
11-44.	Isovelocity gradient	1. Sound energy reflected from the sea surface, bottom, and/or particles dispersing in a random fashion
11-45.	Refraction	
11-46.	Reflection	
11-47.	Scattering	2. Sound waves returning to the water after striking abrupt surfaces
		3. Sound waves in a given water column having the same velocity throughout
		4. Sound waves bending or curving as they pass from one medium to another

In items 11-48 through 11-51, select from column B the oceanographic related term or phrase applicable to each definition in column A.

A. Definitions	B. Terms and Phrases
11-48. The total amount of dissolved solid material, expressed in grams, contained in 1,000 grams of sea water	1. Reverberation 2. Salinity 3. Shadow zone
11-49. The scattering of sound from a source back toward the source	4. Sound velocity
11-50. The rate at which sound energy propagates in relation to temperature, pressure, and salinity	
11-51. The regions in the ocean where sound energy penetration is negligible	

11-52. What does the temperature-salinity (T-S) diagram identify?
1. Water mass and type only
2. Water mass and viscosity only
3. Water type and viscosity only
4. Water type, water mass, and viscosity

11-53. Which of the following statements about the continental shelf is INCORRECT?
1. The shelf extends outward from the coast to a depth of 1,500 fathoms and comprises about 12 percent of the total ocean bottom
2. The shelf region is a transition zone between fresh water runoff from land and the more saline waters of the sea
3. Great mixing of waters and generally unstable water conditions are characteristic of the shelf region
4. Currents in the shelf region commonly run parallel to the shoreline

11-54. What topographic feature covers the largest area of the ocean bottom?
1. Continental shelf
2. Continental slope
3. Ocean basin
4. Ocean deep

11-55. Refer to figure 16-1 in your textbook. The area of the ocean bottom classified as deep can be found only in relation to what topographic feature?
1. Continental shelf
2. Continental slope
3. Ocean ridge
4. Ocean trench

Learning Objective: Identify temperature gradients in relation to depth in the three ocean layers, three ways in which ocean circulation and salinity content relate to solar heat, and two reactions of sound under given conditions.

11-56. Refer to figure 16-2 in your textbook. Which of the following correctly indicates the descending order of the thermoclines as they are ordinarily found in the oceans?
1. Warm and shallow → rapidly decreasing temperature → uniformly cold
2. Warm and deep → rapidly decreasing temperature → uniformly cold
3. Shallow with rapidly decreasing temperature → shallow with temperature decrease slowing → uniformly cold
4. Shallow with rapidly decreasing temperature → uniformly cold → slowly decreasing temperature

11-57. Increases in ocean salinity are primarily caused by
1. conduction
2. condensation
3. evaporation
4. precipitation

11-58. Which of the following statements provides the best explanation for the fact that the deep water in tropical oceans originates in higher latitudes?
1. Water beneath the surface in high latitudes becomes less dense as it flows into the tropics and forces the warmer water under the surface
2. Surface water in the higher latitudes, being less dense than tropical waters, expands over the tropical waters and, in turn, is replaced as it is heated
3. Surface water in the tropical oceans is heated and expands along the surface; as it becomes less dense, the denser water from the polar regions flows in under it
4. Water beneath the surface in tropical oceans is constantly forced deeper by the increase of surface layer pressure thereby allowing cold polar water to flow in over it

11-59. Refer to figure 16-5 in your textbook. How is sound in the illustration being affected?

1. It is reflected from the submarine to the source
2. It is reflected from the shadow zone to the source
3. It is refracted downward by the slight velocity gradient
4. It is refracted upward by the pronounced velocity gradient

11-60. Which of the following is most likely to result when sound is reflected from a solid object in the ocean?

1. Scattered reflection
2. Reflection with little loss in intensity
3. Absorption of reflected sound
4. Reflection with loss in intensity

Learning Objective: Recognize applications of sea surface temperature (SST) observations and some seasonal effects of wind and temperature on the mixed layer, and show the relationship between these oceanographic parameters and appropriate terms and phrases.

11-61. Which of the following have applications for the information provided by sea surface temperature (SST) observations?

1. Antisubmarine warfare (ASW) operations only
2. Ocean fog forecasts only
3. Search and rescue (SAR) operations only
4. ASW and SAR operations and ocean fog forecasts

11-62. Which of the following statements about the mixed layer depth (MLD) is INCORRECT?

1. Of the three ocean layers, the MLD is least stable and, as a result, very little attention is devoted to it
2. Variations in the depth of the mixed layer are influenced by day-to-day heating and cooling
3. Diurnal heating of the ocean's surface will exert most influence down to 30 feet below the surface
4. Seasonal weather influences the variation in the MLD of the world's oceans

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In items 11-63 through 11-67, select from column B the term or phrase applicable to each condition in column A.

	A. Conditions	B. Terms/ Phrases
11-63.	The uppermost layers of ocean water increase to a density greater than their underlying waters and sink to greater depths	1. Instability mixing 2. Advection 3. Convergence
11-64.	The wind blows the surface water out of an area	4. Divergence
11-65.	In areas of vertical boundaries between cold and warm currents, tongue-like protrusions of warm water form under cold water and cold water tongues form over warm water	
11-66.	The winds cause surface water to pile up in an area	
11-67.	Cyclonic wind moves surface waters out of an area permitting their replacement by other waters	

Assignment 12

Fundamental Oceanography; Administration; Publications; Supply; Security

Text: Pages 380 - 420

Learning Objective: Relate temperature gradient, pressure, and ocean bottom topography with sound propagation in the ocean environment, to include identifying reaction of sound rays under given conditions and specified transmissions.

12-1. Refer to figure 16-5 in your textbook. A negative vertical temperature gradient causes sound rays to
1. bend up toward the horizontal
2. bend up toward the vertical
3. bend down toward the horizontal
4. bend down toward the vertical

In items 12-2 through 12-4, select from column B the temperature gradient identified by each definition in column A.

A. Definitions	B. Gradients
12-2. Temperature gradient along a plane at boundaries between water masses or currents	1. Vertical 2. Horizontal 3. Positive
12-3. Temperature decrease with depth	4. Negative
12-4. Temperature change within a given water mass from the surface downward	

12-5. Which type of temperature gradient causes a shadow zone?
1. Positive vertical
2. Positive horizontal
3. Negative vertical
4. Negative horizontal

12-6. The longest sonar ranges are possible under which of the following basic patterns?
1. Negative temperature gradient
2. Isothermal temperature pattern only
3. Isovelocity structure only
4. Isovelocity structure and isothermal temperature pattern

12-7. Which of the following combinations of sea conditions and sound propagation patterns is correct?
1. Negative temperature gradient, positive velocity structure, downward refraction
2. Positive temperature gradient, positive velocity structure, upward refraction
3. Negative temperature gradient, isovelocity structure, downward refraction
4. Positive temperature gradient, negative velocity structure, upward refraction

12-8. Interference of sound beam transmission in shallow water is a result of
1. the depth of the sea in the area only
2. the characteristics of the sea surface and bottom only
3. the speed of sound in the sea area only
4. the depth of the sea in the area, characteristics of the sea surface and bottom, and speed of sound in the sea area

12-9. If a sonar pulse with a wavelength of 500 feet is sounded in water where the depth is 80 fathoms, which of the following statements is a valid assumption?
1. The bottom surface consists of sediment
2. The bottom surface consists of sand and rock
3. Sound is likely to be propagated in the bottom surface
4. Sound is not likely to be propagated in the bottom surface

Refer to figure 16-8 in your textbook. In items 12-10 through 12-16, select from column B the type of deepwater transmission most closely associated with each statement in column A.

A. Statements

12-10. The transmission path takes a conic form with some rays bent up and others bent down by refraction

12-11. The velocity at a depth above the bottom surface must be equal to or greater than the velocity at the surface

12-12. The temperature at the surface is constant within 0.4° F per 100 feet, and velocity increases with depth

12-13. The path prediction is NOT generally a function of velocity gradients

12-14. The transmission is free from surface thermal effects, and most of the sound path is in stable water

12-15. Refracted-reflected-refracted rays are usually found in this type of transmission

12-16. The path consists of upward refractions and downward reflections and allows ranges out to several hundred miles

B. Transmissions

1. Surface dirt
2. Deep sound channel
3. Convergence zone
4. Bottom bounce

Learning Objective: Identify the cause of ocean currents and the effect of the earth's rotation on their direction of flow, and recognize the construction features of the major current systems, their parameters, where they flow, and how and where they influence the earth's climate.

12-17. What is the principle cause of the ocean currents?
1. The prevailing winds
2. The rotation of the earth
3. The gravitational pull of the sun and moon
4. The unequal temperatures of the high and low latitudes

12-18. Due to the rotation of the earth, the pattern of deflection of the ocean surface waters is toward the
1. left in the Eastern Hemisphere
2. right in the Western Hemisphere
3. left in the Northern Hemisphere and toward the right in the Southern Hemisphere
4. right in the Northern Hemisphere and toward the left in the Southern Hemisphere

12-19. Which of the following statements relating to the direction of flow of the ocean currents along the coasts of continents in the middle and low latitudes of the Northern Hemisphere is correct?
1. Cold currents flow equatorward along both the east and west coasts
2. Warm currents flow poleward along both the east and west coasts
3. Cold currents flow poleward along the east coasts, and warm currents flow equatorward along the west coasts
4. Warm currents flow poleward along the east coasts, and cold currents flow equatorward along the west coasts

12-20. Two oceanographic features that have a great influence on the climate of the west coast of northwestern Africa are
1. upwelling and cold currents
2. low salinity and cold currents
3. high salinity and warm currents
4. rapid surface evaporation and warm currents

Refer to figure 16-9 in your textbook in answering 16-49 through 16-55.

12-21. The northern branch of the North Equatorial Current in the Caribbean that flows to the north of Cuba is called the
1. Florida Current
2. Antilles Current
3. South Atlantic Current
4. Gulf Stream System

12-22. The northern extension of the Gulf Stream is called the
1. Florida Current
2. Antilles Current
3. North Atlantic Current
4. North Equatorial Current

12-23. Which North American current is similar to the Kuroshio Current in its flow and climatological influence?
1. North Pacific Current
2. Florida Current
3. Antilles Current
4. California Current

12-24. Before they meet at about 40° S lat, turn eastward, and develop great swirls in the middle section of the South Atlantic, how do the Brazilian and Falkland Currents compare with one another in temperature and salinity?
1. Brazilian - low temperature, high salinity; Falkland - high temperature, low salinity
2. Brazilian - high temperature, low salinity; Falkland - low temperature, high salinity
3. Brazilian - low temperature, low salinity; Falkland - high temperature, high salinity
4. Brazilian - high temperature, high salinity; Falkland - low temperature, low salinity

12-25. Clouds and fog along the southwest coast of Africa are attributed to the
1. Brazilian Current
2. Falkland Current
3. Benguela Current
4. Guinea Current

12-26. What currents of the South Atlantic Ocean and the South Pacific Ocean, bringing similar climatological conditions to the western coasts of Africa and South America respectively, are branches of the West Wind Drift?
1. Peru and Benguela
2. Peru and East Australian
3. Benguela and East Australian
4. East Australian and Falkland

12-27. The currents that warm southern Alaska in winter and cool the west coast of the United States in spring and summer are branches of the
1. Oyashio Current
2. Kuroshio Current
3. Aleutian Current
4. North Pacific Current

12-28. Which of the following areas are characterized by cool summers, relatively mild winters, and a small range of temperatures?
1. East coasts of continents in the lower middle latitudes
2. West coasts of continents in middle and higher latitudes
3. East coasts of continents in the higher middle latitudes
4. West coasts of continents in tropical and subtropical latitudes

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Learning Objective: Indicate horizontal and vertical structures of the earth's water masses, some of their characteristics and factors that contribute to their formation, and relate types of water masses with geographic locations and ocean circulation.

12-29. Which of the following statements about water mass arrangement is NOT correct?
1. Water masses are found to remain within more well defined areas than air masses
2. In middle and low latitudes the vertical arrangement of water masses allows identification of surface, upper, intermediate, and deep water
3. In high latitudes the vertical arrangement of water masses consists of surface, upper, and deep water
4. The upper water in high latitude water masses is similar to the intermediate water there

12-30. Which of the following statements about the formation of a water mass is correct?
1. Water density increases horizontally toward the poles and vertically with depth
2. Water spreads horizontally until it reaches a certain density and then it sinks
3. Vertical and horizontal water density distribution is farthest apart in the middle latitudes
4. A water mass can only be formed when surface waters sink

12-31. Water masses that owe their creation to subsurface mixing are found in the
1. South Atlantic Ocean
2. northern Indian and Pacific Oceans
3. equatorial Indian and Pacific Oceans
4. equatorial Atlantic and Pacific Oceans

12-32. Which of the following statements about central water masses is correct?
1. The central water masses are normally found in relatively high latitudes
2. The source regions for central water masses are between 35° and 40° N and 35° and 40° S
3. The vertical extent of central water masses is relatively deep
4. The separation between the central water mass in the Atlantic Ocean is well defined by the equatorial water

12-33. Central water masses in the South Atlantic, Indian Ocean, and the western Pacific are formed due to the similarity in those areas of
1. circulation only
2. heating processes only
3. cooling processes only
4. circulation, and heating and cooling processes

12-34. Equatorial water masses are characterized by
1. high salinity
2. low salinity
3. high density
4. low density

12-35. Which of the following statements about intermediate water masses is INCORRECT?
1. Intermediate water begins when a water type at the surface sinks into the ocean
2. Gradual mixing of a sunken water type with the waters above and below it create the intermediate water mass
3. Intermediate water lies below central water masses
4. The salinity of intermediate water is greater than the surrounding water

In items 12-36 through 12-40, select from column B the type of intermediate water mass likely to be found at each location in column A.

	A. Locations	B. Types
12-36.	In the Straits of Gibraltar in the Atlantic Ocean	1. Arctic 2. Antarctic
12-37.	Between 20° and 43° in the North Pacific	3. Atlantic Ocean
12-38.	East of the Grand Banks of Newfoundland	4. Indian Ocean
12-39.	Between the South Pole and 10° south in the Pacific Ocean	
12-40.	At the convergence of the Oyashio current and the Kuroshio Extension	

12-41. Deep and bottom water masses are characterized by
1. high density
2. high salinity
3. low density
4. low salinity

12-42. The formation of deep and bottom water masses occurs in
1. equatorial waters
2. the Indian Ocean and the Red Sea
3. midlatitudes of both hemispheres
4. Antarctic waters and the high latitudes of the northern oceans

12-43. The deep and bottom water circulation is completed when those waters return to Subarctic and Subantarctic regions as intermediate waters having become
1. more saline
2. less saline
3. more dense
4. less dense

12-44. Which command is the operational hub of the Naval Weather Service system?
1. FNWC Monterey, CA
2. FWC Norfolk, VA
3. FWF Suitland, MD
4. NWSED Lakehurst, NJ

12-45. Weather records should be mailed to NWSD Asheville, NC no later than the
1. 1st of the subsequent month
2. 5th of the subsequent month
3. 10th of the subsequent month
4. 15th of the subsequent month

12-46. Storm and small craft warnings will be retained for what period of time?
1. One year
2. Six months
3. Three months
4. One month

Learning Objective: Relative to supply functions of Naval Weather Service units, recognize applications of allowance lists, the procurement, funding, and disposition of supplies, and associated supply terminology.

12-47. How much high usage material may be stocked by a shipboard weather unit just prior to an extended cruise?
1. 90-day stock level
2. 180-day stock level
3. A stock level sufficient to complete the cruise
4. A stock level sufficient to complete the cruise, plus a remaining 90-day stock level

12-48. What publication provides a listing of the weather plotting charts used by naval weather units along with instructions for requisitioning them?
1. NA 00-35QL-22
2. NA 50-1G-518
3. NAVAIR 00-500A
4. NAVSUP Pub 2002

12-49. The procedures for requisitioning Meteorological Technical Publications may be found in what manual?
1. NA 50-1G-518
2. NAVSUP 2002
3. NA 00.35QL-22
4. NA 50-1P-11

12-50. Assume that a naval air station on the east coast has a broken meteorological instrument in excess. What procedure must be followed to dispose of this instrument?
1. It should be returned to the nearest secondary stock point
2. It should be returned to the nearest meteorological stock point
3. It should be tagged and marked with the appropriate data and shipped to NAS, Norfolk
4. It should be tagged and marked with the appropriate data and shipped to the nearest secondary stock point

12-51. The MILSTRIP system centers around the ordering of what supplies?
1. Those required to fill allowances
2. Those required on a routine basis
3. Those required in excess of allowances
4. Those required to replace equipment for repair

12-52. Which of the following items of information to be placed on Requisition Form DD 1348 is of least concern at the AG3 and AG2 levels?
1. Priority
2. Unit of issue
3. Accountability
4. Requisition delivery date

12-53. Will a station have to expend money from its quarterly allotment to purchase an item with a stock number of 2R6660-339-4319-HO35?
1. Yes, the item is APA
2. No, the item is APA
3. No, the item is NSA
4. Yes, the item is NSA

12-54. Major meteorological equipment used by NWSED, Memphis, is paid for from funds allocated to
1. NWSED's OPTAR
2. FLEWEAFAC Norfolk
3. the host command
4. NAVWEASERVFAC Pensacola

12-55. Shipboard meteorological operating expenses are paid from funds allocated to the weather division from the
1. research fund
2. aircraft operations fund
3. ship's OPTAR
4. special purpose fund

In items 12-56 through 12-58, select from column B the definition of each supply term listed in column A.

A. Terms

12-56. Inventory

12-57. Obligation

12-58. Survey

B. Definitions

1. An unfilled order which will be a charge against the allotment upon receipt of the material
2. The expenditure of property from the records due to loss, damage, deterioration, or normal wear
3. The total amount of an item physically within a command
4. A provision made whereby local commands can finance routine operation and maintenance

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Learning Objective: Relate given weather publications with types of information they contain, and indicate why standard subject identification codes are used in naval communications messages.

12-59. Which of the following publications contain directions for the management and operation of the Naval Weather Service?
1. NAVWEASERVCOMINST 5400.1
2. NAVWEASERVCOMINST 3140.1A
3. NW 20-1D-510
4. NW 50-1D-509

12-60. The environmental services and support available to assist operational Navy weather units ashore and afloat in accomplishing their mission are identified in
1. NAVWEASERVCOMINST 5400.1
2. NAVWEASERVCOMINST 3140.1( )
3. NW 20-1D-510
4. NW 50-1D-509

In items 12-61 through 12-66, select from column B the contents of each Federal Meteorological Handbook (FMH) listed in column A.

A. FMHs

12-61. FMH No. 1, NAVAIR 50-1D-1

12-62. FMH No. 2, NAVAIR 50-1D-2

12-63. FMH No. 3, NAVAIR 50-1D-3

12-64. FMH No. 4, NAVAIR 50-1D-4

12-65. FMH No. 5, NAVAIR 50-1D-5

12-66. FMH No. 6, NAVAIR 50-1D-6

B. Contents

1. Instructions for taking and recording radiosonde observations
2. Codes and coding instructions for meteorological observatons performed by all agencies concerned with weather observation, recording, and reporting
3. Instructions for observing and recording winds aloft observations
4. Detailed information and instructions for taking and recording surface observations

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12-67. A Navy directive that has permanent reference value and is effective until the originator cancels or supersedes it is classed as a/an
1. Notice
2. Bulletin
3. Memorandum
4. Instruction

12-68. While none of the following types of naval correspondence requires transmission by electrical means, which is handled most expeditiously?
1. Speedletter
2. Joint letter
3. Naval letter
4. Memorandum

Learning Objective: Recognize the necessity for classified material security, techniques used in effecting a security program, security classification categories, and procedures associated with stowage, use, transmission, accounting, disposition and destruction of classified material.

12-69. Which of the following statements best describes the phrase "need to know" when used regarding security of classified material?

1. Although an individual has received a security clearance, his access to classified material is governed by his need to know about such information in order to carry out his duties
2. Everyone in the Navy needs to know and be fully aware of the situation confronting his organization because history has shown that a well-informed military man does the best job
3. No individual below the rank of chief petty officer should have any need to know anything of a classified nature because security may be compromised
4. Anyone that holds a particular billet must have access to classified material related to all phases of his assigned duties

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In items 12-70 through 12-73, select from column B the security classification applicable to each classification requirement listed in column A.

A. Requirements

12-70. Material which would compromise military plans important to the national defense

12-71. Material which would reveal important intelligence operations

12-72. Material which would compromise technological developments vital to national defense

12-73. Material which would be prejudicial to national defense

B. Classifications

1. Top Secret
2. Secret
3. Confidential

12-74. If an emergency occurs, who is responsible for safeguarding classified material out of its proper storage?

1. The top secret control officer
2. The intelligence officer
3. The person in possession of the material at that time
4. The operations officer

12-75. The top secret control officer ensures continuous positive control of the Top Secret material under his jurisdiction by

1. requiring all people who require it to remain in the security office while they use it
2. requiring each person who uses it to sign a receipt for it in order to have a record of all who have had access to it
3. requiring the messenger who delivers the material to sign for and accept the custodianship of it
4. issuing a numbered copy of it to everyone who needs one, thus transferring the custodianship of it to them

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